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DECEMBER, 1919

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THE TERMINAL ABDOMINAL STRUCTURES OF ORTHOPTEROID INSECTS: A PHYLOGENETIC STUDY.

By E. M. WALKER, Toronto, Ont.

INTRODUCTION.

There is still much difference of opinion concerning the inter-relations of the various orders of insects, particularly of the so-called "lower" orders, and even the question as to what are the limits of these orders is by no means a matter of general agreement.

If these problems are ever to be solved in a logical manner, all the available data must be taken into account. The evidence afforded by comparative anatomy, ontogeny and palaeontology, or any facts bearing upon the subject, must all be fairly considered. Although much information has been accumulated from these various sources, there are still important fields which have received much less attention than they deserve. In the field of external morphology the greatest advances have been made in the study of wing-venation, which, thanks to the classical labors of Comstock and Needham, now rests upon a thoroughly sound basis; the mouth-parts have also long been a favorite subject for investigation, while in comparatively recent years, good progress has been made in the study of the thoracic and cervical sclerites, particularly by Snodgrass and Crampton.

Our knowledge of the terminal abdominal structures, especially the genitalia and associated parts, is still, however, in a very unsatisfactory state. A constantly increasing value is being attached to them by systematists in separating genera

and species, but the specialist is seldom interested in these structures except in so far as they afford good taxonomic characters in the groups with which he is concerned, and does not trouble himself to inquire into their homologies with the corresponding parts in other orders. The natural result of this is a multiplicity of terms and a great lack of unanimity in their application.

The most fundamental upheaval of our generally accepted ideas of insect classification that has occurred in comparatively recent years is the system advocated by the eminent student of fossil insects, Anton Handlirsch. This system, which was first proposed in 1903,[1] and elaborated in 1908 in his monumental work, "Die fossilen Insekten," is well known, and its deviations from previously accepted views are due mainly to the study of the fossil record. His division of the old class Insecta (Hexapoda) into five classes—Collembola, Campodeoidea, Protura, Thysanura and Pterygogenea—is not based directly upon palaeontological evidence, but on general considerations of structure; but the splitting up of the old order Orthoptera is founded upon the actual fossil record, so that the question as to whether or not the findings of comparative morphology support his views becomes one of considerable importance.

The present study of the genitalia and associated parts of the groups commonly called Orthoptera is offered as a contribution to this subject and, at the same time, an effort has been made to clear up certain general questions on the homologies of the parts concerned.

Before proceeding with the discussion of the terminal abdominal structures, it may be useful to give a brief summary of Handlirsch's views in so far as they relate to the origin and relationships of the various groups still commonly known as Orthoptera, i. e., the Blattidæ, Mantidæ, Phasmidæ, Acrididæ and Acrydiidæ (Tettigidæ)*, together with such other groups as may appear to be more or less closely related to them.

The earliest undoubted insect remains belong to the Carboniferous era. They are all winged insects of comparatively large size, some of them very large. Eleven orders are recog-

[1] Handlirsch, 1903. Zur Phylogenie der Hexapoden. Vorläufige Mitteilung. Sitzb. K. Akad. Wiss., Bd. 112, Heft 8, Abt. 1, pp. 716–738, Taf. 1.

* The Acrydiidæ of Most Authors.

nized by Handlirsch as belonging to this period, only one of which, the Blattoidea, is represented among the orders of the present age, although four others, viz., the Protorthoptera, Protoblattoidea, Protodonata and Protephemeroidea, appear to be the direct forbears of the Orthoptera, Mantoidea, Odonata and Plectoptera (Ephemerida) respectively.

A large proportion of the insects of this period are characterized by their extremely generalized structure and are regarded by Handlirsch as the groups from which all other winged insects, or Pterygogenea, have descended. These are the Palaeodictyoptera. Their two pairs of ample wings were similar in size, form and venation, the latter being remarkably like the hypothetical type on which the Comstock-Needham system is founded.

The Protoblattoidea and Protorthoptera are independently connected with the Palaeodictyoptera by forms which differ very slightly from the latter, while, on the other hand, the most primitive Blattoidea, such as *Polyctoblatta*, grade almost insensibly into the Protoblattoidea. The latter group consisted of more elongate forms than the true Blattids, having a less regularly elliptical outline, and usually a longer prothorax and a more exposed and prognathous head. Some of them, at least, had a well-developed exserted ovipositor.

The Protoblattoidea died out in the Permian, where the first true Mantids appeared, these differing in venation very little from the former group.

The Blattoidea are considered to be the forbears, not only of their modern representatives, but also of the Isoptera, Corrodentia (Psocidæ), Mallophaga and Siphunculata (Anoplura). None of these groups are known before the Tertiary epoch, and the fossil record offers no clues as to their relationships. Handlirsch is probably correct with respect to the Isoptera, although they may well have arisen at a much earlier age than the Cretaceous.

The Protorthoptera, which also persisted into the Permian, embraced a considerable number of families and genera. They were elongate forms, some with ambulatory legs and prognathous phasmid-like heads, while others had saltatorial hind legs like those of modern Orthoptera. An elongated ovipositor was present in some, if not all, forms(e. g., *Dieconeura arcuata* Scudd.) None possessed stridulatory organs.

No Orthopteroid insects are known from the Trias, the insect record of which is very scanty, but true Orthoptera appear in the Lias, belonging to several groups, some of which were silent while others possessed stridulating organs.

Among the former were the Locustopsidæ, which had antennæ and an ovipositor of the Tettigoniid type, but wing venation more like that of the Acridoidea, and, like the latter, lacked the stridulatory apparatus in the male tegmina. True Acridoidea are known from the lower Tertiary, so they were probably derived from the Locustopsidæ during Cretaceous times. The stridulating forms were in part, at least, true Gryllidæ, and Handlirsch concludes that from primitive non-stridulating saltatorial stock two branches arose, one leading to the common ancestors of the Gryllidæ and Locustidæ (Tettigoniidæ), the other giving rise to the Elcanidæ and Locustopsidæ, from which latter the Acridioidea were evolved. He regards the Tridactylidæ as probably derivatives of the Elcanidæ, some of which, like *Tridactylus*, possessed peculiar lobe-like swimming appendages on their hind tibiæ.

Other orders which Handlirsch assigns to the Orthopteran stem are the Dermaptera, "Diploglossata" and Thysanoptera. These groups are unknown below the Tertiary epoch, and this fact has evidently influenced Handlirsch's judgment in his attempt to find suitable ancestors for them in the Orthoptera of the Cretaceous.

The Ephemerida, Odonata and Plecoptera are considered to have no direct relationship with each other or with other orders except through their Palaeodictyopterous ancestors.

Since the publication of "Die fossilen Insekten," two new orders of insects have been discovered which must be considered in any discussion of the phylogeny of the orthopteroid groups. These are the Zoraptera, represented by a single genus, *Zorotypus* Silvestri ('13)[2] containing five species, and the Grylloblattoidea, likewise represented by one genus, *Grylloblatta* Walker ('14)[3] with a single species (*G. campodeiformis*). The former group is compared by its author with the Isoptera and Blattidæ and also with the Dermaptera (*teste* Caudell) and

[2] Silvestri, Fil., Ballet. Lab. Zool. Gen. Agric. Portici, Vol. VII, pp. 193–209, Figs. i-xiii (1913).

[3] Walker, E. M., Can. Ent., Vol. XLVI, pp. 93–99, Pl. VI (1914).

Crampton ('15)[4] considers them as probably members of the "Panisoptera," to which the first two named groups belong. Caudell[5] likewise finds their nearest allies in the Isoptera. Unfortunately, I have been unable to obtain specimens of *Zorotypus* and can therefore add nothing to what has already been written concerning it.

The systematic position of *Grylloblatta* has been discussed in several papers by Crampton[6], as well as in the original description by the present writer (loc. cit.). Its extraordinary synthetic character is indicated by the variety of orders with which it has been found to have important features in common.

As regards Prof. Crampton's opinions on the relationships of the Orthopteroid orders in general, a few words may be said here. He has expressed views on this subject in several papers ('15, '16, '17, '18, '19)[7] and these have been modified somewhat from time to time, especially with regard to the position of Grylloblatta, which will be discussed later. His latest views appeared in a paper entitled "Notes on the Phylogeny of the Orthoptera," and are summarized in his diagram on p. 43 ('19).[7] They differ from those of Handlirsch mainly in the following points:

1. The Isoptera, owing to the possession of certain primitive characters not found in living Blattids and Mantids, are represented as arising, not directly from the Blattid branch, but from the base of the common stem of the Blattidæ and Mantidæ, or possibly somewhat farther along its path of development.

2. The Phasmidæ arose, not from Saltatorial Orthoptera (Locustopsidæ), but from near the base of the common Orthopteran stem, a view which is supported particularly by the presence of Plecopteroid characters in the primitive Phasmid, *Timema californica*.

3. The Dermaptera are likewise not regarded as of Orthopteran origin, but are separately derived from the common stock, from which all the pterygote orders arose.

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[4] Crampton, G. C. Ent. News, Vol. XXVI, p. 343 (1915).

[5] Caudell, A. N. Can. Ent., Vol. L, p. 381 (1918).

[6] Crampton, G. C., Ent. News, Vol. XXX, pp. 42–48, 64–65 (1919). (See also following footnote.)

[7] Crampton, G. C., Ent. News, Vol. XXVI, pp. 337–350, Pl. XIII (1915); Ent. News, Vol. XXVII, pp. 244–258, 297–307 (1916); Can. Ent., Vol. XLIX, pp. 213–217, Fig. 9 (1917); Ent. News, Vol. XXVIII, pp. 398–413, Pl. XXVII (1917); Journ. N. Y. Ent. Soc., Vol. XXV, pp. 225–237 (1917); Bull. Brooklyn Ent. Soc., Vol. XIII, pp. 49–68, Pls. II–VII (1918); Ent. News, Vol. XXX, pp. 42–48; 64–72 (1919).

4. The Dermaptera, Embiidina and Plecoptera are grouped together more closely than is done by Handlirsch, who recognized no near affinities among them.

In other respects Crampton's diagram is not incompatible with Handlirsch's views, so far as it goes, but in regard to the relationship of other orders not included among the "Orthopteroid" groups, but believed by Handlirsch to be derived from Orthopteroid ancestors (including Blattoid and Protoblattoid derivatives) his views are very different. These, however, do not concern us here.

In general Crampton believes that the Plecoptera rather than the Blattoidea most nearly represent among living insects the ancestral stock from which the Orthoptera and Phasmoidea have developed, while Grylloblatta has its closest affinities among the Mantids, Embiids and Dermaptera, and its line of descent is therefore represented as coming from the ancestral stock common to the Panisoptera and Panplecoptera. This view differs somewhat from former views expressed by this same author, in which he placed Grylloblatta in his super-order "Panorthoptera," with the Orthoptera and Phasmoidea. The position of this important annectant form will be further discussed at a later stage.

THE TERMINAL ABDOMINAL STRUCTURES.

Two papers by Crampton ('17 and '18)[8] have recently appeared, in which these structures in the more primitive orders are discussed from the comparative standpoint. In the earlier paper, which deals with the female, the author states that "the neck and cervical structures furnish far more definite characters for grouping these insects than the terminal abdominal structures of the female do," and in another paper already cited ('19, p. 64), he emphasizes the phylogenetic importance of the former structures on account of their being remarkably constant within an order or superorder and less subject to such variations as depend upon changes of function. While admitting the general truth of this statement, it should be kept in mind that such characters as were present in the common ancestors of all insects may be inherited by some of

[8] Crampton, G. C., Jour. N. Y. Ent. Soc., Vol. XXV, No. 4, Pls. XVI, XVII (1917); Bull. Brooklyn Ent. Soc., Vol. XIII, pp. 49-68, Pls. 2-7 (1918).

the members of any of the orders, and that they may therefore be of little phylogenetic value except in determining the primitive form of the structure concerned or in deciding which forms in a particular group are its most primitive members. Specialized characters, when the factor of convergence can be eliminated, are often of more value than primitive ones, particularly in complex structures where an opportunity for detailed comparison is present. For instance, the arrangement of the mouth-parts of the Diptera or the Lepidoptera is so distinctive that these structures alone serve as recognition marks of these orders. It is largely this feature which renders wing-venation so useful in phylogenetic studies of insects, and although I should not attribute the same value to the genitalia, I do claim that they are of great phylogenetic importance when studied in detail; and in this connection I may point out that Prof. Crampton's studies of the thoracic and cervical sclerites are very much more thorough than those of the genitalia. The chitinous parts of the genitalia are in large measure internal structures and unless their internal relations are carefully investigated one is certain to be led to false deductions.

In another recent paper by Dr. A. G. Newell ('18)[9] the view is held that the gonapophyses in both sexes represent three pairs of serial appendages or limbs, belonging to the 8th, 9th and 10th abdominal segments; and an attempt is made to identify these appendages in both sexes of all the orders. Although a useful summary of the literature dealing with the subject of insect genitalia is given, the investigation itself betrays a lack of grasp of the fundamental principles involved, and the facts of comparative morphology and development as given in the bibliography cited appear to have been almost entirely ignored.

The material on which the present study is based was obtained from various sources. For the gift or loan of specimens, indispensable to the work, I am especially indebted to the following gentlemen, to whom I take pleasure in expressing my most sincere thanks: Prof. G. C. Crampton, Dr. C. Gordon Hewitt, Dr. N. Banks, Dr. L. O. Howard, Mr. Thos. E. Snyder, Mr. Morgan Hebard and Mr. W. Downes.

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[9] Newell, Anna Grace, Annals Ent. Soc. Am., Vol. XI, No. 2, pp. 109–142, Pls. IV–XVI.

Part I. The Terminal Abdominal Structures of the Female.

The female external genitalia of a typical generalized Pterygote insect (e. g., *Ceuthophilus*, Figs. 1–4), consist of the *vulva* or genital aperture, situated at or near the posterior end of the eighth abdominal sternum and usually protected by a backward prolongation of the latter (in some cases the seventh sternum), the *subgenital plate* (st. 8); and three pairs of processes, the *gonapophyses* or *valvulæ*, which co-operate to form the ovipositor. These valvulæ are distinguished, from their usual positions, as the *ventral*, *dorsal* and *inner valvulæ* (valves) or the *anterior*, *lateral* and *posterior gonapophyses*, respectively. The ventral valvulæ arise primitively from the posterior margin of the eighth sternum, though often actually from the intersternal membrane between segments eight and nine; the dorsal and inner valvulæ from the ninth sternum, primitively also from the posterior margin.

The ventral valvulæ (vv) consist of a shorter basal segment, the *basivalvula* (Crampton, '17)[10] and a longer *shaft*. The basivalvula (bs) is usually chitinized only ventrally or ventrolaterally, if at all, the shaft externally, when a functional structure, but becoming partly or entirely membranous when the ovipositor is degenerate.

The dorsal valvulæ (vd) may be more or less distinctly separable into a broad proximal portion and a longer, more slender distal part, but there is no line of demarcation between these parts and nothing comparable to the basivalvulæ; the parts so designated by Crampton being in some cases the lateral part of the ninth sternum (or valvifer, *vide inf.*)[11]; in other cases merely the basal part of the valvula itself,[12] the appearance of a suture being due to parts beneath showing through the valve.

The inner valvulæ (vi) are enclosed by the other two pairs and are usually the shortest pair. They commonly enclose or roof over, the passage through which the eggs are passed out

[10] Crampton, Journ. N. Y. Ent. Soc., Vol. XXV, p. 236 (1917). Also termed "Basalstück" (Van der Weele, Tijd. voor Ent., Deel XLIX, pp. 99–198, Pls. 1–3, 1906), and "basal plate" (Walker, Univ. of Toronto Studies, Biol. Ser., No. 11, 1912).

[11] Crampton, op. cit., Pl. XVI, Fig. 7; Pl. XVII, Fig. 12.

[12] Crampton, op. cit., Pl. XVI, Figs. 1, 6; Pl. XVII, Fig. 10.

in oviposition. Very frequently the inner valves are connected from the base distad to a varying extent by a fold of integument, which may be termed the *intervalvular membrane* (im). The inner valvulæ are generally chitinized laterally and these hardened parts or *rami* (rm) are connected by a strengthening bar or *pons valvularum* (p) across the membrane, or the entire fold may be chitinized dorsally. In the former case it is sometimes convenient to distinguish proximal and distal portions of the rami according to their position in relation to the pons. Like the ventral valvulæ, the dorsal and inner pair may be largely or wholly membranous when functionally degenerate.

Between the bases of the dorsal valvulæ and often closely connected or even fused with them, is a median sclerite, the *superior intervalvula* (sv). It bears a median vertical apodeme for the attachment of important muscles connected with the movements of the ovipositor, and its outer surface is continuous below with the upper surface of the intervalvular membrane. In some forms, such as *Mantis* and *Stagmomantis*, the rami of the inner valves may be fused with this plate. Another median sclerite, the *inferior intervalvula* (iv), is found on the ventral surface of the base of the intervalvular membrane. With the inferior intervalvula the rami of the inner valvulæ are frequently connected, as in the Tettigoniidæ and Acrididæ, and they are always connected more or less closely with a strong ventral process from the base of each dorsal valvula, which may be termed the *inferior apophysis* (iap). A similar but usually larger process, the *superior apophysis* (sap) projects forward into the hæmocœle from the upper part of the base of the valvula. Both pairs of apophyses serve for muscular attachment.

The dorsal and ventral valvulæ meet laterally at their bases, where they are both joined by a small plate, of more or less triangular form, the *valvifer* (Crampton)[13] (vf). This sclerite represents the antero-lateral part of the ninth sternum and its outer (upper) anterior angle is connected with an apodeme in the form of a ridge following the constriction between segments 8 and 9 (ap. 9, int. ap.). The ridge is generally continued along the front margin of the valvifer and also often along the lateral margin (using these terms in a morpho-

[13] The "épimerite" of Lacaze-Duthiers. Ann. Sc. Nat., 3 série, Zool., tome 17, pp. 207–251, Pls. 10, 11, 12 (1852).

logical sense), and near its lower end it is sometimes raised into a prominent internal process (pap) for the attachment of muscles. In the Acridoidea this process reaches an enormous size, although the valvifer and ridge are greatly reduced or absent.

Distal Valvular Connections.

The manner in which the valvulæ are connected beyond the base varies greatly, depending upon differences in the methods of oviposition. As a rule the dorsal and ventral valvulæ form a sheath enclosing the inner valvulæ, the dorsal frequently overlapping or roofing over both ventral and inner valvulæ. Very frequently the inner and ventral valvulæ fit together more or less firmly by a tongue-and-groove joint extending along their adjacent outer edges for the greater part of their length, and in some cases (most Tettigoniidæ) such a joint also occurs between the dorsal and ventral valvulæ. In both cases the ventral valvulæ bear the groove or grooves, the other valvulæ the tongues. Where such connections exist the only possible movements of the valvulæ in relation to one another are sliding movements backwards and forwards. These are best seen in the Tettigoniidæ and doubtless also occur in *Grylloblatta*. In the Gryllidæ, in which the inner valvulæ are vestigial, the dorsal and ventral pair are immovably united with one another at the apices and no movement takes place between them. In the Acrididæ, Acrydiidæ and Tridactylidæ (*Ripipteryx*), on the other hand, the dorsal and ventral valvulæ are free beyond their bases, and can be moved in the sagittal plane like a pair of forceps, of which the dorsal pair form one of the jaws, the ventral pair the other. In the Phasmoidea, Mantoidea and Blattoidea, the valvulæ are more or less flexible and apparently not functional in the forms studied. There is no close connection between them beyond the base, although there is usually an ineffective tongue-and-groove engagement between the inner and ventral valvulæ.

Development of the Ovipositor.

The first indication of the ovipositor (Fig. 9) is generally a pair of tubercles on the ninth sternum, sometimes on the hind margin, but more frequently farther forward. These are soon followed by two other pairs, one from the hind margin of the eighth sternum, or just behind it, the other from the ninth

sternum (Fig. 10), between the first pair and sometimes a little in front of them. The outer pair on segment 9 form the dorsal valvulæ, the inner pair the inner valvulæ, while the pair from segment 8 become the ventral valvulæ. Where styli occur, they may appear at an earlier stage than the papillæ, which are destined to form the valvulæ, and invariably occupy the same position as the outer papillæ of the ninth sternum, so that as these elongate into the valvulæ they carry the styli with them as small apical appendages. The styli, in all Orthopteroid insects, ultimately disappear or become indistinguishable from the apices of the dorsal valvulæ, but in many Odonata, including all the Zygoptera and some of the Anisoptera (Aeshninæ and Petalurinæ of the Aeshnidæ), well-developed styli persist in the adult females as functional organs.

In early larval life, when the first rudiments of the ovipositor appear, the abdominal segments are of relatively uniform size, decreasing in length but little towards the caudal extremity. In forms with a well-developed ovipositor (Orthoptera, Grylloblattoidea, Mantoidea), however, as development proceeds, the tenth segment becomes relatively smaller and the ninth deeper, so that, when maturity is reached, the sternal region of segment nine is shifted from a horizontal to a nearly vertical position, thus bringing the bases of the dorsal and inner valvulæ into the same transverse plane with those of the ventral valves. An enlargement of the bases of the valvulæ usually accompanies their increase in length and this brings about a crowding out, as it were, of such portions of the ninth sternum as are not occupied by the ovipositor itself. Thus, in the adult, the lateral areas are represented merely by the valvifers, while the median parts are the intervalvular membrane and the superior and inferior intervalvulæ.

In contrast to the reduction of the ninth sternum, the eighth sternum is usually prolonged caudad as the subgenital plate covering the vulva and bases of the ventral valvulæ. In some groups (Blattoidea, Mantoidea and Isoptera) it is, however, much reduced and hidden by the greatly developed seventh sternum, which replaces it as a subgenital plate. In such cases the eighth sternum becomes more or less completely dechitinized.

The important question as to the homologies of the valvulæ will be deferred until after the consideration of both the male and female structures in the various groups.

Orthoptera.

Tettigonoidea (Tettigoniidæ).

As the ovipositor and associated parts in this group reach a high state of development and are at the same time of a remarkably generalized type, it seems best to consider it first.

The ovipositor varies enormously in length, form and armature, but with these features we need not be concerned. It will suffice for our purpose to examine one of the more primitive and one of the more specialized types.

Of the genera studied, we have found the most primitive types of ovipositor in the cricket-like forms belonging to the Stenopelmatinæ and Rhaphidophorinæ. The well-known "stone-crickets" belonging to the genus *Ceuthophilus*, of the latter subfamily, illustrate this type well.

In *Ceuthophilus* (e. g. *C. lapidicola* Burm.) (Figs. 1–4), the ovipositor shows comparatively little tendency towards the pronounced lateral compression or blade-like character of the more typical green grasshoppers and katydids. It is subcylindrical in the stouter basal part, becoming more compressed distally. The dorsal valvulæ overlap the other two pairs, completely concealing the inner valvulæ, and there is no tongue-and-groove connection between the dorsal and ventral valvulæ, such an engagement existing only between the ventral and inner valvulæ. The ventral valvulæ are closely applied together, meeting along the mid-ventral line. The basivalvulæ are distinct, though not heavily chitinized and are not wholly concealed by the rather small subgenital plate. Between the basivalvula, ninth tergite and base of the dorsal valvula, is the subtriangular valvifer, the upper angle of which is articulated with the ectal margin of the base of the dorsal valvula. Its antero-dorsal and antero-ventral margins are raised internally into strong ridges, (Fig. 4), the latter being continuous with the intertergal apodeme, which runs for a moderate distance along the front margin of the ninth tergite and terminates abruptly.

The inner edges of the dorsal valvulæ meet at a point near the base, proximad of which they diverge again slightly, but at the extreme base (excluding the superior apophyses) they are closely united by the small triangular superior intervalvula, which, as usual, projects beneath as a median vertical apodeme.

The superior apophyses are triangular processes of average length. The inferior apophyses curve inwards to meet the inferior intervalvula, which is a large, thin, sagittiform plate.

The inner valvulæ are much shorter than the other two pairs and are somewhat widely overlapped by the dorsal valvulæ. The rami are connected across the well-developed intervalvular membrane, a little beyond its middle, by the broad pons valvularum, and are articulated at their bases with the inferior intervalvula behind the inferior apophyses. A portion of the proximal division of the rami is separated from the remainder by a distinct joint. The inner valvulæ are apparently supported by a strong chitinous process projecting inwards from the inner surface of the dorsal valvulæ at point about opposite the posterior limit of the intervalvular membrane.

The ninth and tenth segments are very short and the tenth tergite, as in all the groups of true Orthoptera, does not form a complete ring, there being a distinct though unchitinized sternal area. The eighth spiracle occupies the pleural membrane near the edge of the tergite.

The cerci are long and taper from a stout base to a slender apex. They are unsegmented, but it may be noted that in males of some species of the closely allied genus *Pristoceuthophilus* (e. g. *P. cercalis* Caudell) a few small segments are present at the apices of the cerci. Although this is very probably a caenogenetic character, it is of interest in connection with the other primitive characters met with in the subfamily Rhaphidophorinæ.

As an example of the more specialized type of ovipositor in the Tettigoniidæ, we may take *Conocephalus fasciatus* De Geer (Figs. 5–8). The ovipositor of this species is straight and sword-shaped, the valvulæ being more strongly compressed and closely coherent than in *Ceuthophilus*. Both dorsal and inner valvulæ engage the ventral valvulæ by tongue-and-groove joints, the groove in each case running along the edge of the ventral valvulæ. The basivalvula is not a distinct plate, but there is a flattened ventral area, which is evidently its equivalent. It is but little chitinized, except in its ventrolateral edge. The superior intervalvula is larger than in *Ceuthophilus* and shows a distinct external pocket or invagination and a well-developed median apodeme, extending down-

wards and forwards. It articulates closely with the dorsal valvulæ. The pons valvularum occupies the entire distal half of the intervalvular membrane and is continued cephalad as a slender median process, which meets the under side of the superior intervalvula, but does not fuse with it. In some species, such as *Tettigonia verrucivora*, according to Dewitz ('75)[11], there is an actual fusion with this plate. The inferior intervalvula is a slender transverse bar, whose outer ends are closely articulated with the rami of the inner valvulæ, and less intimately with the inferior apophyses of the superior valvulæ, which terminate beyond the articulation in an upwardly bent spine. The dorsal apophyses are larger than in Ceuthophilus, but not essentially different. The valvifer and intertergal apodeme do not differ materially from those of Ceuthophilus.

The end segments are more elongate than in this genus, the tenth segment and anal valves more prominent. The cerci are shorter and there is a distinct cercal basipodite.

The female genitalia of *Ceuthophilus* may be regarded as somewhat more primitive than those of *Conocephalus* in the following characters: The distinct basivalvulæ, the less compressed ovipositor and the less complete cohesion of the valvulæ due to the absence of the tongue-and-groove joint between the dorsal and ventral valvulæ. The more elongate and flexible cerci might also be included, but it is in the males (*vide postea*) that they show a decidedly more primitive form than in *Conocephalus*.

Finally, it may be added that in the Tettigonoidea in general the supra-anal plate is not divided transversely into two sclerites, as is commonly the case in the females of Acridioidea, i. e., there is no separate eleventh tergite; and it is not always sharply marked off from the tenth tergite. The paraprocts are generally but little chitinized.

Grylloidea (Gryllidæ).

In this group, as in the preceding, the ovipositor is typically long and slender, but, although sometimes compressed and ensiform or falcate, it is usually cylindrical and more or less enlarged apically, the enlarged part armed with teeth. In the Gryllotalpinæ or mole-crickets the ovipositor has wholly disappeared in adaptation to the subterranean habits.

[11] Dewitz, H., Zeits. wiss. Zool., Bd. XXV, pp. 174–200, Taf. 11, 12 (1875). (*Tettigonia verrucivora* referred to as *Locusta viridlissima*.)

We may take as an example of the family the common field cricket (*Gryllus assimilis* Fabr.)

In this species (Figs. 11–15) the eighth and ninth tergites are very short in the mid-dorsal line, but the ninth expands considerably on the sides and extends farther ventrad than the others. The seventh sternum is very large, but is not produced caudad as a free flap, while the eighth sternum forms a small subgenital plate, similar to that of the Tettigoniidæ. The eighth spiracle occupies the pleural membrane close to the tergal margin. The tenth tergite is laterally very short, but is dorsally longer and fused with the supra-anal plate, though the line of fusion is visible. The paraprocts are larger and more heavily chitinized than is usual in the Tettigoniidæ. The cerci are long, flexible and tapering, with numerous hairs and sensillæ, being very similar to those of *Ceuthophilus*, though larger.

The valvifer is very large and is produced under cover of the subgenital plate into a strong process, which probably represents a part of the basivalvula. Its inner surface is without strong marginal ridges, but bears a stout process or apodeme, directed ento-caudo-dorsad. Its antero-dorsal angle is connected, as usual, with the ninth tergal apodeme, which is well developed. There is also a similar but weaker eighth tergal apodeme.

The ventral valvulæ are without distinct basivalvulæ, but these are represented by a well-defined unchitinized area, covered by the subgenital plate, and probably also by the ventral processes of the valvifers.

The dorsal valvulæ are peculiar in the sudden expansion of their bases, this part forming part of the sternal surface rather than the valves themselves. Between these bases and partly fused with them is the relatively large superior intervalvula. Like that of *Conocephalus*, its lower part is deeply depressed and it is also similarly produced cephalad into a thin median apodeme. The superior and inferior apophyses are well developed and the latter are connected by a transverse bar, which represents the inferior intervalvula.

The shafts of the dorsal and ventral valvulæ fit closely together by a tongue-and-groove joint and their enlarged apices are locked together by a peculiar structure, consisting of a projection from the dorsal valvula, which fits into a socket in the ventral valvula.

The inner valvulæ are extremely vestigial and quite membranous. They project backward from the lower part of the superior intervalvula. They were overlooked by Lacaze-Duthiers (loc. cit.), who mistook the dorsal valvulæ for them, owing to their close connection with the inferior intervalvula, which is suggestive of the connection in many Tettigoniidæ between this plate and the rami of the inner valvulæ.

In *Oecanthus* (Figs. 16–18, *Oe. quadripunctatus* Beut.) the genitalia do not differ from those of *Gryllus* except in comparatively unimportant details. The most striking feature is the exceedingly powerful ninth tergal apodeme, which forms a complete arch around the base of the tergite; and the otherwise feebly chitinized dorsal surface of segments 9 and 10. These features are doubtless related to the habit of the genus of ovipositing in woody stems, which would require a greater development of the muscles of the ovipositor than is necessary in such ground-dwelling species as *Gryllus assimilis*.

The dorsal and ventral apophyses and the ventral prolongation of the valvifer are also longer than in *Gryllus*.

The general proportions of the abdominal segments and terminal structures are somewhat suggestive of some *Tettigoniidæ* and of *Grylloblatta*, but there are no indications of relationship with the latter form, as has been more than once suggested by Crampton, who has been apparently influenced by superficial resemblances of form. As far as the terminal abdominal structures are concerned, *Oecanthus* is more specialized than *Gryllus*, and if anything even less like *Grylloblatta* than the latter genus is.

Acridoidea (Acrididæ, Acrydiidæ).

The appearance of the ovipositor in this superfamily is singularly different from that of the two preceding groups, but the fundamental similarity of its structure in all three was demonstrated long ago by Lacaze-Duthiers ('52, *loc. cit.*) and Graber ('70)[15]. Its peculiarities in the Acridoidea are chiefly modifications connected with the different method of oviposition. The dorsal and ventral valvulæ function as a pair of forceps for digging the hole, usually in the ground, in which the eggs are deposited. Each pair of valves acts as one of the

[15] Graber, V., Sitzb. K. Akad. Wiss., Bd. LXI, Abtl. 1, pp. 597–616, 1 Pl. (1870).

blades of the forceps, the movement being in the sagittal plane. The inner valvulæ take no part in this process, but serve to roof over the path along which the eggs are passed out.

As a type of the group we may take the common two-striped locust (*Melanoplus bivittatus* Say.) (Figs. 22–25). In this species the eighth tergite is well developed, but the ninth and tenth are not only greatly shortened, but are fused laterally, the intersegmental furrow being imperfectly developed. The supra-anal plate is divided by a transverse suture, the basal part probably representing the eleventh tergite, while the apical part is the tergite of the anal segment or telson. There is also a distinct cercal basipodite, which may represent a separated lateral portion of the eleventh tergite. The cerci themselves are very short and unsegmented. The paraprocts are broad, flat and well chitinized, and are not completely separated from the tenth tergite at the lateral margin.

The abdominal tergites are in reality pleuro-tergites, since they bear the spiracles, a short distance from their lateral margins. This feature is more pronounced in the Acrididæ than in other families of Orthoptera. The eighth sternum forms a large subgenital plate and terminates in a papilliform process called the "egg-guide," another characteristic Acridian structure.

The ventral valvulæ are short and very stout at base, but taper to a slender decurved hook-like apex. They are peculiar in that the tegument is divided into five distinct sclerites, of which the lateral and the three ventral ones constitute the basivalvula, while the long dorsal one represents the shaft. This is evident by comparison with *Acrydium* in which there are but three sclerites. The dorsal valvulæ are of about the same length as the ventral, and the apices are likewise hook-like, but curved upwards. They are narrowly separated at base, the interval being occupied by the small superior intervalvula, which lacks the usual median apodeme, but has two slight prominences for muscular attachments.

The superior apophyses are represented only by thin flat tendons of the powerful elevator muscles of the dorsal valvulæ. The inferior apophyses (Fig. 24), on the other hand, are stout processes which bend inwards from the base of the valvulæ to articulate with the inferior intervalvula. This plate has the form of a curved bar, from the concave side of which a bifurcate

process arises. The inferior apophyses join the ends of the bar, while the arms of the bifurcate process are connected with the rami of the inner valves. These connections are thus quite similar to those of the Tettigoniidæ (cf. *Ceuthophilus*).

The inner valvulæ are very short, but not vestigial as in the Gryllidæ. They are connected almost to their apices by the intervalvular membrane, the rami being united distally by a V-shaped pons valvularum.

Extending cephalad from the basal articulation of the dorsal and ventral valvulæ into the body-cavity as far as the seventh segment is a somewhat flattened and heavily chitinized rod (pap), which is entirely concealed in an external view. This structure appears as though grooved externally, but the groove is covered over with thin chitin, so that it is really a tubular invagination. It serves for the origin of the most powerful muscles of the valvulæ, i. e., the elevators of the dorsal and depressors of the ventral valvulæ. Its morphological nature has been the subject of differences of opinion. Lacaze-Duthiers (*loc. cit.*) interpreted it as the "épimerite" (valvifer), while Graber (*loc. cit.*) thought it represented the superior apophysis of the dorsal valvulæ. The latter interpretation is obviously incorrect; the former is much nearer the truth. The muscles, which in other Orthoptera arise from the ninth tergal apodeme and its vicinity and are inserted into the superior apophyses, take their origin in the Acrididæ from this rod, the apodeme being undeveloped in its usual situation. It will be remembered that this apodeme is continuous with that of the lower edge of the valvifer in the Tettigoniidæ and other groups, and that it tends to be best developed towards its lower end, where it is sometimes raised into a distinct process (e. g. *Diapheromera*, *Stagmomantis*). As the muscles which usually connect the valvifer with the superior intervalvula arise in *Melanoplus* also from this process, it appears that the latter represents in part the lower end of the tergal apodeme and in part the valvifer. That it does not represent the main body of the latter is clearly shown by an examination of both nymph and adult of one of the small grouse-locusts (Acrydiidæ, more commonly known as Tettiginæ). Fig. 28 represents the end-segments of the female nymph of *Acrydium ornatum* Say. Here we find a perfectly typical valvifer of considerable size. In Fig. 26, which is taken from an adult *Acrydium*, the valvifer is also

present, but is very small and sub-chitinized. The characteristic rod (pap) is fully developed and is separate from the valvifer, but its base of attachment is in very close relation to the latter; in fact, in an internal view of the nymph, they appear to be in contact with one another.

The first appearance of this rod in the nymph of Melanoplus is a slight invagination of the soft chitin at the angle between the valvular bases. This is later continued cephalad as a thin band-like tube, as seen in the last nymphal stage, assuming its final form only at the last moult. No external appearance of the valvifer is present in Melanoplus.

In respect of the presence of a distinct valvifer in the Acrydiidæ we may consider the latter to be a more primitive family than the Acrididæ and this view is borne out by other features of the terminal segments. In the nymph of *Acrydium*, e. g., the ventral valvulæ possess unmistakable basivalvulæ (bs), which, however, in the adult became divided into two sclerites, a lateral and a ventral, the latter representing the two principal ventral sclerites in Melanoplus. The ninth and tenth tergites are quite separate and less reduced than in Melanoplus, especially in the nymph. The tenth tergite (Fig. 29) is imperfectly divided into median and lateral regions, of which the former is less heavily chitinized and is produced caudad into a lobe which divides the eleventh tergite into two separate lateral plates. The supra-anal plate also shows two lateral chitinized areas. In the nymph (Fig. 29), the eighth and ninth tergites are unmodified, but in the adult they also present a narrow, less densely chitinized median region, which folds inwards, allowing the lateral parts to come together in a pointed or Gothic arch.

These peculiar features are very suggestive of the Tridactylidæ, which also resemble the Acrydiidæ in some other respects. The cerci are divided into a stouter basal part, which is hairy, and a slender smooth apical part. This gives them the appearance as though composed of two fused segments, a feature which is also suggestive of some Tridactylidæ (q. v.).

In other respects the female genitalia closely resemble those of the Acrididæ, the larger size of the superior intervalvula in *Acrydium* as compared with that of *Melanoplus* being perhaps the most striking difference noted.

The eighth spiracle, as in other Acridioidea, is situated in the tergite (pleuro-tergite), but the others retain a more primitive position in the pleural membrane.

Tridactyloidea (Tridactylidæ).

This small family has been commonly associated with the Gryllidæ, owing to the superficial resemblance of the typical genus, *Tridactylus*, to the mole-crickets (Gryllotalpinæ), a resemblance due to the subterranean habits of both. Thus we find in both *Tridactylus* and *Gryllotalpa* a similar form of head and pronotum, short antennæ, front legs adapted for digging and reduction of the ovipositor, which in *Tridactylus* is vestigial, while in *Gryllotalpa* it is entirely wanting. In the Tridactylid genus, *Ripipteryx*, however, which is not a distinctly subterranean form, there is a well-developed ovipositor, and it is not at all like that of a Gryllid, but is remarkably similar to that of the Acridoidea, as suggested by de Saussure and Zehntner ('94).[16] These authors, however, failed to appreciate fully this resemblance and made no comparisons between the two groups.

I have examined the terminal segments and ovipositor of *Ripipteryx forcipata* Sauss. (Figs. 19–21), and find the latter to be closely comparable with that of the Acridoidea, but with certain important features of its own.

The obliquity of tergites 9–11, which is slightly indicated in *Acrydium* and associated with the weakening of the median region and a breaking up of the dorsum into a number of secondary sclerites, occurs in the Tridactylidæ in an exaggerated form. In *R. forcipata* the eighth tergite is normal in shape and form except that it is divided along the mid-dorsal line into two lateral plates, the thin tegument between the plates being folded inwards. This is also the case in a slighter degree in *Acrydium*. The ninth tergite is also completely divided into two lateral plates, but the obliquity has been carried so far that the original anterior, ventral and posterior margins are respectively ventral, posterior and dorsal in position. The antero-dorsal angles of these plates extend forward underneath the eighth tergite as two slender processes, which are apparently all there is to represent the dorsal region. The tenth tergite lies dorsal to

[16] Rev. Suisse de Zool., tome II, Fasc. 2, pp. 403–430, Pls. XVI, XVII (1894).

the ninth, and consists of two narrow lateral plates prolonged forward into a pair of slender, curved bars, which pass between the similar processes of the ninth tergite, under cover of the eighth tergite, but meet in the middle line between the two main parts of the latter and three other small plates which apparently represent the median elongated portion of this tergite in *Acrydium*. The eleventh tergite is possibly represented by the two small oblique plates at the base of the supra-anal plate, and two others laterad of these at the bases of the cerci (cercal basipodites). These relations are also similar to those of the Acrydium. The cerci are short, cylindrical and unsegmented, although in Tridactylus they are distinctly two-segmented, and in certain other species of *Ripipteryx* (*R. mexicana* Sauss.) they are imperfectly divided into a number of secondary segments (de Saussure & Zehntner, loc. cit.).

The supra-anal plate is similar in form to that of Acrydium but is semi-membranous and undivided. It varies, however, considerably in form in different species of the family, as do also the subdivisions of the abdominal tergites, so that it is questionable to what extent these parts are really homologous to those of the Acrydiidæ.

The paraprocts are of very remarkable form, being greatly elongated, with a terminal segment like a pair of styli or a second pair of cerci. These, however, have nothing to do with true styli, for which they were mistaken by Crampton ('18)[17]; for the styli, when present in female insects, are always borne by the dorsal valvulæ or their homologues, and thus belong to the ninth segment. These peculiar structures, which are present in both sexes in *Tridactylus* as well as *Ripipteryx*, were correctly interpreted by de Saussure and Zehntner as outgrowths of the paraprocts.

Another feature possessed by *Ripipteryx* in common with *Acrydium* is the position of the eighth spiracle in the eighth tergite, and the other spiracles in the pleural membranes.

Turning to the sternal region, we find that, except in the case of the eighth, the sternites overlap the tergites instead of vice-versa. The eighth sternum forms the subgenital plate, but is not specially modified for the purpose and lacks an egg-

[17] Bull. Brooklyn Ent. Soc., Vol. XIII, No. 7, Pl. V, Fig. 48, 1918.

guide. The basivalvulæ are of enormous size and have the appearance of a divided subgenital plate, for which they were mistaken by de Saussure and Zehntner.

The ovipositor as already noted, is essentially Acridian in type. The dorsal and ventral valvulæ are sigmoid in form, the apices of the dorsal valvulæ curving upwards, the ventral pair terminating in sharp, decurved hooks, and having also a shorter external hook (cf. *Melanoplus*, Figs. 22, 23). In de Saussure and Zehntner's Figure (l. c., Pl. XVII, Fig. 27) what is evidently the same hook is represented as belonging to the dorsal valvulæ, but this is certainly an error, due to the valvulæ having been tightly closed in the specimen drawn. As in most Acridoidea there is no trace of the valvifer, while the free chitinous rod (pap) is represented by a prominent, shelf-like apodeme (ap 9), extending from the angle between the valvulæ along the ventral edge of the ninth tergite and projecting a short distance under the eighth. This ridge is quite similar in relation to the valvulæ to the free rod of the Acridoidea, but is a true ninth tergal apodeme, like that of the Gryllidæ and Tettigoniidæ. It is in this feature that the genitalia of the Tridactylidæ differ most from those of the Acridoidea.

The dorsal valvulæ, as in the Acridoidea, lack distinct superior apophyses. The superior and inferior intervalvulæ have precisely the same positions as in that group, but are even smaller and simpler in form. The inferior intervalvula is a slender transverse bar resembling that of *Gryllus* in form and is connected at its outer ends, separately, with both the small inferior apophysis and the rami of the inner valvulæ. The latter are, as in the Acridoidea, very small, but lack the intervalvular membrane and pons.

There are many other points of resemblance between the Tridactylidæ and Acridoidea, and taking all these into consideration, we can hardly doubt that the nearest relations of the former are the Acridoidea rather than the Gryllidæ.

Grylloblattoidea (Grylloblattidæ).

The female genitalia of the Orthoptera are most nearly approached by those of *Grylloblatta*, so that we may consider this form next.

A glance at the end-segments and ovipositor of *Grylloblatta* (Figs. 31–35) at once recalls the Orthopterous families Gryllidæ and Tettigoniidæ, except in the segmented cerci, which are more like those of certain Plecoptera, or to a less extent, the Mantidæ. The form of the eighth, ninth and tenth segments is very like that of *Conocephalus*, though more depressed and the tenth segment more prominent. The eighth sternum is not flap-like, but quite generalized in form, although a median pale or thin area is present, which marks the small cavity into which the vagina opens.

The ninth tergite (Fig. 31) is somewhat prolonged ventrad as in *Gryllus*, the ventro-cephalic margin being oblique, as is usual in the Tettigoniidæ and Gryllidæ. The tenth tergite in the adult female is fused with the sternite forming a complete ring, as in many Plecoptera. Its dorsum is slightly prolonged behind the bases of the cerci, but does not overlap the supra-anal plate, which is quite distinct, though small. Both supra-anal plate and paraprocts, which are subchitinized, are quite like those of many Tettigoniidæ. The spiracles, which are very small, are all situated in the pleural membrane.

In the external form of the valvulæ and their connections with neighboring sclerites *Grylloblatta* is remarkably like a primitive Tettigoniid, such as Ceuthophilus. The most conspicuous, but not the most important difference is in the basivalvulæ, which are more clearly defined and more heavily chitinized, recalling those of the Mantids. The valvifer has exactly the same relations as in the Tettigoniidæ. Its lower angle articulates with the ecto-basal angle of the ventral valvula, not being prolonged under the subgenital plate as in *Gryllus* and *Oecanthus*. There are well-marked internal ridges along its upper and lower margins, the latter being continuous with the ninth tergal apodeme, all these features recalling *Ceuthophilus* or *Conocephalus* strongly.

The ovipositor is much like that of *Ceuthophilus* or related genera, though the valvulæ are less compressed and not so closely applied to one another, the ventral ones, particularly,

being slightly separated from one another along the mid-ventral line and from the dorsal valvulæ along their entire length. The dorsal valvulæ do not overlap the ventral valvulæ on the sides, so that the inner valvulæ are not concealed as in the Tettigoniidæ. The inner valvulæ are a little shorter than the ventral, with which they are connected by a tongue-and-groove joint of the same character as in *Ceuthophilus*, i. e., there is a narrow groove with raised edges along the upper margin of the ventral valves, into which fits a ridge along the lower margin of the inner valves.

In order to study the inner connections of the valvulæ the abdomen of the original paratype specimen was cut across at the base of segment seven, and the posterior segments treated with potash.

Fig. 32 shows the ovipositor in dorsal view, with the left ventral valve forcibly turned outwards; the right valve is omitted. The dorsal valves are separate from one another except near the base, where they meet at little more than a point, the inner margins then diverging again. The superior apophyses are very like those of *Ceuthophilus* (Fig. 1) and the articulations with the valvifer quite similar. The inferior apophyses are prolonged inwards into a pair of slender curved bars, which meet one another in the middle line. These evidently represent the inferior intervalvula, but are in no way distinct from the apophyses.

The inner valvulæ fit closely into the concavities of the dorsal valvulæ, there being no space between the two pairs such as we usually find (cf. *Ceuthophilus*). The intervalvular membrane is well-developed as is also the pons which unites the rami just beneath the point where the dorsal valvulæ meet. The median part of the pons projects below from the upper surface, as a bilobed prominence (Fig. 35, pp), which recalls the transverse thickened portion of the superior intervalvula in the Mantids (Figs. 35, 49). No median apodeme could be found, however, and it is to this apodeme that the muscles arising from the valvifers are attached in the Mantidæ, Tettigoniidæ and Gryllidæ. This apodeme, when present, is situated between the valvifers, the muscles running transversely and if such an apodeme were present in this position in *Grylloblatta* it would lie considerably in front of the bilobed prominence.

The fact that the valvifers are well chitinized and bear the usual ridges for muscular attachment seems to indicate, however, that the muscles in question are probably present and yet no sclerite for their inner attachment was found, unless it be the bilobed prominence. As compared with *Ceuthophilus* this prominence would appear to belong to the pons, but in any case it seems probable that the pons was primitively not distinct from the superior intervalvula, as is indeed the case in such forms as the Mantids where no distinct intervalvular membrane is developed. With the great development of this membrane in the Tettigoniidæ, however, the pons became differentiated, retaining its connection with the superior intervalvula in some forms (e. g., *Tettigonia*) while becoming entirely separated from it in others, such as *Ceuthophilus*. Although the matter requires further investigation, it may be considered probable that the superior intervalvula is at least partly represented by the bilobed prominence beneath the pons. If this is the case, *Grylloblatta* differs from all the other forms studied in which the superior intervalvula is present in that this sclerite does not connect the bases of the dorsal valvulæ, but lies beneath them.

The rami of the inner valvulæ are fused with the inferior apophyses which, as stated above, is not distinct from the inferior intervalvula. This firm union of the dorsal and inner valves, together with the manner in which the latter fit closely within the former, would seem to prohibit any independent movements of the inner valvulæ.

A short distance behind the united inferior apophyses is the opening of the receptaculum seminis, a small, thick-walled rounded pouch.

The female nymph—(Figs. 36–38). The only known specimen of the female nymph was recently described by the writer ('19)[18] and is nearly full grown. The eighth sternum is similar to that of the adult, except that it is uniformly, though feebly, chitinized. The ventral valvulæ arise just behind the sternal margin and are straight, subcylindrical processes, bluntly pointed at the apices. The basivalvulæ are clearly defined by a transverse groove. The sternal region of segment nine still has its primitive horizontal position in line with that of segment

[18] Walker, E. M., Can. Ent., Vol. LI, 11, pp. 131–139. 1919.

ten. Across its middle arise the dorsal and inner valves in the same transverse plane. They are likewise of subcylindrical form, the inner valvulæ pointed like the ventral pair, while the dorsal valvulæ have well-developed styli upon their apices, a primitive feature, unlike any of the Orthoptera at so late a stage. Judging by the comparative lengths of the valvulæ the styli evidently go to form the apices of the dorsal valvulæ. There is no trace of the intervalvular membrane, this structure being doubtless formed from the median part of the sternal area, both before and behind the bases of the inner valvulæ. The remaining parts of the sternum go to form the valvifers (antero-lateral region) and the broad bases of the dorsal valvulæ (postero-lateral region).

It will be seen that at this stage the ovipositor of *Grylloblatta* is distinctly more primitive in character than that of a Tettigoniid nymph of corresponding stage. This is seen in the form and position of the valvulæ and in the presence of styli. In these respects they approach the Blattidæ and Mantidæ, but the valvulæ of the ninth segment have not the terminal position, nor have the dorsal valvulæ the broad, flattened form found in these groups. In these respects the Blattids and Mantids are the more primitive and *Grylloblatta* occupies a position between them and the Tettigoniidæ.

Phasmoidea.

In this well circumscribed order the ovipositor is of a somewhat primitive type and is, at the same time, more or less degenerate and probably functionless in most cases. It is generally largely concealed by a hood-like subgenital plate, which as in the Orthoptera, is the eighth sternum. The end-segments (8 to 10) show no tendency to become abbreviated and the sternal surface of segment nine retains its primitive horizontal position in the same plane with that of segment ten. The abdominal spiracles are all situated in the pleural membrane. The cerci are always relatively short and unsegmented and the anal valves (supra-anal plate and paraprocts), though prominent, are not usually large nor densely chitinized.

In the remarkable little Phasmid, *Timema californica* Scudd. (Figs 39, 40), the genitalia appear to be of very primitive form, but they may perhaps be more correctly described as of

a "larval" type, i. e., they are probably to be looked upon as degenerate, functionless structures, whose development has been arrested at an early stage, as is not uncommonly the case in degenerate structures. The eighth sternum is but little produced over the bases of the ventral valvulæ, which are slender and flexible with broader basivalvulæ. The ninth segment is shorter than usual in this order, but the sternum is horizontal, its lateral parts, the valvifers, being larger and having a larval position in relation to the dorsal valves of the ninth tergite. They were erroneously regarded as basal segments of the dorsal valvulæ (basivalvulæ) by Crampton. The dorsal valvulæ are flexible, triangular flaps, whose bases meet the inner edges of the valvifers exactly. The term "dorsal" is here inappropriate, as they retain the larval position external to the inner valves, with which they are fused to within a short distance of the apices of the latter. Neither dorsal nor inner valvulæ are connected with the ventral pair. Having seen only one specimen of *Timema*, which was kindly lent by Prof. Crampton, I have not studied the internal relations of the valvulæ.

The tenth tergite is rather long dorsally, but narrowed ventro-laterally. Its apex is somewhat produced over the supra-anal plate, which like the paraprocts, is rather long and pointed, though but thinly chitinized. The cerci are large and stout.

A less primitive ovipositor, but more typical of the order, is that of the common stick-insect, *Diapheromera femorata* Say. (Figs. 41–43). The valvulæ of this species are of considerable size, but quite soft and flexible. They are flattened dorso-ventrally and arched towards the anus. The inner valvulæ lie as in *Timema* in the primitive position between the dorsal valvulæ (although in some genera they lie dorsal to the latter), with which they are united in a similar manner. This connection seems to be characteristic of the Phasmoids and it was for this reason that the inner valvulæ were mistaken by Lacaze-Duthiers ('52, loc. cit.) for a part of the dorsal valvulæ. There is little development of the intervalvular membrane and the rami are represented only by a short chitinous process on each side, at the angle of union with the dorsal valvulæ, these processes ending freely, there being no trace of either superior or inferior intervalvulæ. The underside of the inner valvulæ bears a very distinct though flexible ridge (Fig. 43), which fits

in a corresponding groove in the ventral valvulæ (Fig. 41), but as the parts are soft no union is thus obtained. The dorsal valvulæ do not lie so flat as in *Timema*, but the primitive widely separated position is retained, their bases not becoming arched dorsad over the inner valvulæ. Their only strongly chitinized parts are the superior apophyses which are well developed and a small process just above the angle with the ventral valvulæ, and apparently representing the inferior apophyses. There is no trace whatever of the valvifer, but there is a small process (pap) which seems to belong to the lower extremity of the ninth tergal apodeme. Both valvifer and apodeme, however, may be well developed in the Phasmoidea as shown by Lacaze-Duthiers in the genus *Acrophylla*. Their absence in *Diapheromera* is a degenerative feature. The basivalvulæ are also absent in this genus. The subgenital plate is of large size, but much smaller than in many other genera. The tenth segment is large, with an extensive sternal area, but the supra-anal plate and paraprocts, though prominent are much smaller than in *Timema*. The cerci are also relatively smaller.

There is considerable variation in the Phasmids in the size of the subgenital plate, the relative lengths, form and position of the valvulæ, but a firm, coherent structure, such as the ovipositor of the Orthoptera and Grylloblattoidea, does not, so far as we are aware, occur in this order. The apparently primitive form of the Phasmoid ovipositor may be largely due, as already suggested in the case of *Timema*, to imperfect or arrested development, but at the same time, it is probable that the Phasmoid ovipositor never reached a high degree of development.

Mantoidea (Mantidæ).

Of the single family comprising this order two species were studied, *Stagmomantis carolina* L. and *Mantis religiosa* L. They are so much alike in the parts with which we are concerned, that we may confine our attention in the main to the former, this having been the form which was most thoroughly studied.

In *Stagmomantis* (Figs. 44–49) there is a marked abbreviation of the eighth and ninth tergites, which also extend a shorter distance ventrad on the sides than the seventh and preceding

segments, so that they are separated from their sterna by a wider extent of pleural membrane. The tenth tergite is also laterally reduced, but is prolonged backwards over the supra-anal plate, taking the place of the latter, which is greatly reduced and feebly chitinized, as are also the larger paraprocts. The spiracles are all situated on the tergites, near their lateral margin. The cerci consist of about 15 short segments, which are but little flattened.

The ovipositor is of considerable size, but almost entirely concealed by a huge hood-like structure, which is the seventh sternum and is therefore not the homologue of the subgenital plate of the groups thus far discussed. Under cover of this hood and adherent to it is a bifid plate (Fig. 44), which overlaps the vulva. This is part of the eighth sternum and apparently the homologue of the subgenital plate of the Orthoptera and Phasmoidea. The vulva lies between a pair of median shelf-like valves. Extending forward from between the base of the valves is a thick fold with a chitinized edge (ar), upon which is a small opening of the spermatheca. In the natural position of the parts this orifice lies just above the vulva. The valvulæ are large, but of irregular shape and only partly chitinized. The dorsal pair overlaps the ventral and both are distally decurved and peculiarly lobed at their blunt apices. The ventral valvulæ are widely separated for some distance from their bases, this space apparently serving for the exit of the ova and secretions which form the ootheca. The basivalvulæ are usually distinct and heavily chitinized, being the firmest parts of the valvulæ. Just above the basivalvula is a small, but well-chitinized valvifer connecting the dorsal and ventral valvulæ in the usual way. In Crampton's figure of the ovipositor of *Stagmomantis*[19] this plate is incorrectly labeled "basivalvula" (i. e., of the dorsal valvulæ). It bears only one apodeme, parallel to the antero-ventral margin and continued as a strong ridge across the pleural membrane to the tergites of segments eight and nine, opposite the intersegmental groove, where it is expanded into a short broad spur (pap), and is thence continuous with the short tergal apodemes of these two segments. (Fig. 48). The pleural apodeme is a thickening of the intersegmental furrow, and is marked externally by a distinct groove.

[19] Jour. N. Y. Ent. Soc., Vol. XXV, Pl. XVI, Fig. 7, 1917.

The dorsal valvulæ are close together and at their extreme bases they are joined by a fold of tough cuticle. Just behind this fold is the large superior intervalvula, which unites the two bases closely with one another and with the inner valvulæ. It consists of a stout, bilobed transverse bar connected below with a thin horizontal plate (hlm), which projects forward into the body and bears a median apodeme, which has the same muscular connections with the valvifers as that of the Gryllidæ and Tettigoniidæ.

The dorsal apophyses are short but stout, the ventral rather slender, but well chitinized and firmly united with the large, thin, ventral intervalvula. The inner valvulæ are of moderate length, but very close together, not enclosing a passage for the exit of the eggs. There is a considerable space between their lateral surfaces and the dorsal valvulæ. Like the other valvulæ, they are lobed and ridged, and they engage the ventral valvulæ ineffectively, by a slight tongue-and-groove joint. There is practically no intervalvular membrane and no pons, but the rami are strongly chitinized and fused with the transverse bar of the superior intervalvula. Their anterior extremities, however (Fig. 49), lie below the level of this sclerite on each side of the horizontal plate (hlm) which seems to represent an invaginated intervalvular membrane. There is no connection between the ends of the rami and the inferior intervalvula, such as occurs in the Orthoptera.

A pair of small lobes project back from the inferior intervalvula between the inner valves. (cf. Blattoidea).

Blattoidea (Blattidæ).

In the cockroaches we find many of the peculiarities of the Mantidæ in a more pronounced form, as well as special characteristics of their own. The ovipositor is not only degenerate, but more or less greatly atrophied and completely concealed by the large "subgenital plate," which as in the Mantidæ is the seventh, not the eighth sternum. Crampton (*loc. cit.*, p. 227), states that in the superorder Pandictyoptera, (later termed Panisoptera and including Blattidæ, Mantidæ and Isoptera), "the ventral portion of the terminal abdominal segments is typically overlapped by a backward prolongation of the eighth segment." He considers Holmgren (Termitenstudien. Anat-

omische Untersuchungen, 1909) as being incorrect in designating this segment in the Isoptera as the seventh, believing that the first abdominal segment is not developed ventrally in this order. Allowance is made by Holmgren, however, for the missing segments for the subgenital plate is the sixth sternum by actual count except in some forms where a vestige of the first persists.

This enlarged seventh sternum is prolonged back to the end of the abdomen, thus enclosing a very large "genital cavity" (or "anal cavity," as it is sometimes called), in which the ovipositor is entirely hidden. In some genera such as *Periplaneta* and *Blatta* it bears a pair of apical moveable valve-like plates, which serve to close the opening of the genital cavity.

The eighth and ninth tergites are usually greatly abbreviated and the tenth tergite, though laterally narrowed and not continued inwards beneath the cerci to any extent, is often considerably produced backward between the cerci, overhanging the anus and substituting the supra-anal plate, which in adult cockroaches is wholly wanting. This tenth tergite is commonly termed the supra-anal plate by systematists, but it is better to restrict this term to the structure to which it has been generally applied, otherwise it loses its morphological significance.

The disappearance of the supra-anal plate in the Blattids and its substitution by the tenth tergite is the more complete expression of the same tendency indicated in the Mantids, where the true supra-anal plate, though present, is reduced and entirely covered by the tenth tergum. A similar condition is met with in the Isoptera (q. v.).

The Blattids also resemble the Mantids in having segmented cerci, though these are shorter and more flattened, and in many other respects, which will be noted in the following account.

As an example of a typical Blattid with a fairly well developed ovipositor we may take the common native cockroach, *Parcoblatta pensylvanica* De Geer, better known as *Ischnoptera pensylvanica*. Fig. 52, is an oblique or ventrolateral view of the terminal segments of this species, the seventh sternum ("subgenital plate") having been removed. Fig. 51 is a ventral view of the same parts, omitting those of the tenth anal segments. Fig. 51 is a similar view, but with the valves of the ovipositor forcibly bent forward and the right dorsal valvula cut away from the base.

The ventral valvulæ, like those of the Mantids, are irregular, only partly chitinized and spread apart towards their bases. But here a strange modification is seen. The bases are suddenly enormously expanded and connected with one another by an arcuate, chitinous band, which narrows at the sides and, passing around behind the base, joins a broader plate in this situation. This arcuate band, or its equivalent, varies greatly in form in different Blattids and is clearly the homologue of the transverse sclerite (ar) or chitinous edge of the fold in the Mantids which bears the opening of the spermatheca. It appears to be a special characteristic of these two nearly allied orders. The posterior plates referred to are the basivalvulæ, which have reached this position by the spreading apart of the bases accompanied by an outward rotation. A similar shifting of the valve bases is noticeable in the Mantidæ, but is much less pronounced. In the immature *Parcoblatta*, up to the last instar, no such peculiarities are seen, the ventral valvulæ being close together with typical basivalvulæ, and this simple condition is retained in the adult of *Cryptocercus punctulatus* Scudd. (Fig. 59), the ovipositor in this form having been apparently arrested in development, in a manner closely comparable to that of the Phasmid *Timema californica* (see pp. 292-3).

Immediately behind each basivalvula is the large valvifer, which, as usual, connects the bases of the dorsal and ventral valvulæ and is continuous at its antero-lateral angle with a strong apodeme, which follows the constriction between segments eight and nine to the tergal margins of these segments and is in every way comparable to the similar apodeme in the Mantids. The valvifer is thus widely separated from the tergal margins by a membranous area, which is crossed by the intersegmental apodeme, their relations being essentially the same as in the Mantidæ, and but little different from those which are typical of the Orthoptera, in which the ninth tergal apodeme is really the homologue of the intersegmental apodeme. The longitudinal groove of the apodeme is plainly seen and marks the constriction between the two segments.

Between the valvifers are two large plates which are continuous with the shafts of the dorsal valvulæ, from which they are strongly bent outwards and downwards. These are simply the bases of the dorsal valvulæ, and are not unlike the expanded bases of these structures in *Gryllus*. The dorsal valvulæ are

decidedly folded and irregular on the dorsal side and bilobed at the apices, though ventrally smooth. There is a prominent sub-basal process on the dorsal side (pvd) but it is unchitinized. It is perhaps represented in the Mantids by a minute lateral lobe, which is present in this situation. The expanded bases are united behind by a narrow strip of chitin, in front of which, closely connected with the bases, is the peculiarly shaped superior intervalvula. There is also a pair of short spurs (sap) which may represent the superior apophyses (not present in all Blattidæ) and a pair of slender rods with thin, anterior expansions, (iap), which surround the bases of the inner valves and meet in a somewhat heavier median portion (iv), just behind the ventral valve bases. These rods evidently represent the inferior apophyses, while the thicker median piece is the inferior intervalvula. The spermatheca opens a little behind this plate; in other forms, such as *Blatta*, directly upon it.

The inner valvulæ have much the same form as in *Stagmomantis* and as in this genus they are slender, close together, and lie in the hollow of the dorsal valvulæ, close to the latter and engage the ventral valvulæ very feebly. In their slightly expanded, flexible apices, the lack of a true intervalvular membrane, and the presence of a pair of ventral basal lobes, they also recall the Mantids. They are not fused with the superior intervalvula, however, but are connected with the latter by a peculiar ball and socket joint, the dorsal surface of the fused valve bases bearing a knob, which fits into a socket in the transverse part of the superior intervalvula. In front of the knob the fused valve-bases form a thin plate which is curved upwards (hlm). This plate is similar in position to the plate (hlm) in *Stagmomantis* (Figs. 45, 49) and is doubtless its homologue, as in *Stagmomantis* this plate is likewise continuous with the bases of the inner valvulæ, as well as the superior intervalvula, of which it appears to form a part.

It will be seen from the foregoing description that, in spite of wide differences in the form and proportions of the various parts they are essentially similar in the Blattids and Mantids, the differences being of small weight, as compared with the many points of resemblance.

In addition to the structures described, there is a rather large, though ill-defined chitinized area behind the bases of the dorsal valves (ca), and serving for the attachment of muscles.

This is a secondary deposit of chitin and does not represent a definite sclerite. It is not present in all Blattidæ.

A narrow chitinized strip possibly represents the tenth sternum in *Parcoblatta*. The supra-anal plate is wholly absent in the adult though its vestige is present in the young nymph. The paraprocts, on the other hand, are large, broad and rather flattened and the dorsal surfaces strongly chitinized. The cerci are of the usual Blattid type, the basipodite developed on the inner instead of the outer side.

The immature Blattid (e. g., *Parcoblatta*, Figs. 55–57) is remarkable for the very primitive condition of the ovipositor, which is indicated, (1) by the fact that the valvulæ all develop from the hind margins of their corresponding segments; (2) in the manner in which the dorsal valvulæ develop (*vide infra*); (3) in the broad flat form of their valves, as distinct from the slender inner and ventral valvulæ (cf. the Thysanura, Fig. 72), and (4) in the persistence of styli on the dorsal valvulæ until the last moult.

Development of the ovipositor (*Parcoblatta*). The stages here outlined were first described by Denny ('94)[20] in the case of *Blatta orientalis* L. and are well known, but their significance has not been sufficiently emphasized. Figs 55, 56, 57 and 58 represent ventral views of segments eight and nine, a portion of seven (the seventh sternum being nearly all removed), of three immature stages and the adult *Parcoblatta pensylvanica*. The youngest nymph (Fig. 55) differs little from the male of the same stage except in the presence of a pair of small processes, on the hind margin of the eighth sternum and a small apical median fissure of the ninth sternum. Both sterna are well developed. In the next stage (Fig. 56) the eighth sternum is much narrower; the two little processes are greatly elongated and are marked off from the sternum by a slight constriction. They are now distinguishable as the ventral valvulæ, and the basivalvulæ are also indicated in the median sternal region. The two stylus-bearing lobes into which the sternum is divided have become relatively narrower, and the fissure between them has greatly deepened and widened at base, from which the rudiment of the inner valvulæ have arisen.

[20] Denny, A., Rept. 63, Meeting Brit. Assoc. Adv. Science, p. 818 (1894).

In the third stage (Fig. 57) which represents the last nymphal instar, the eighth sternum is still narrower and has lost its disto-lateral angles. The ventral and inner valvulæ have changed but little, but the two lobes of the ninth sternum have greatly decreased in width, though the styli are practically unchanged. They are now clearly recognizable as the dorsal valvulæ.

The metamorphosis of this primitive condition into the complex structure of the adult is a transformation worthy of a higher order of insects, but the most significant feature in the entire process is the clear indication that the dorsal valvulæ are a part of the ninth sternum, and are homologous with the flat, stylus-bearing sternal lobes or "coxites" of the Thysanura. Their comparatively late development is no objection to their interpretation as such primitive structures, in view of the well-known fact that organs, which are not functional until adult life is reached, are frequently retarded in development.

The ovipositor of *Cryptocercus punctulatus* (Fig. 59) presents an interesting structure intermediate between that of the adult and late nymphal stages of more typical roaches, such as *Parcoblatta*. The ventral and inner valves are quite like those of an immature roach, while the dorsal valves have something of the mature form, but are unusually simple. The valvifer is of remarkably generalised form and together with the well-marked intersegmental apodeme bears a closer resemblance to these structures in the Mantids, than is found in any other Blattid I have examined.

The ovipositor of *Cryptocercus* is, however, very degenerate, the valvulæ and valvifers being very feebly chitinized and their inner connections greatly simplified. Thus, in view of the many details held in common by the more complex types of Blattid ovipositor and that of the Mantids, the simple structure found in *Cryptocercus* must be looked upon as at least partly due to arrested development, or the persistence of a larviform condition, rather than a truly primitive one. It is closely paralleled in the Phasmoidea by *Timema californica*.

It may be added that in certain respects *Cryptocercus* is highly specialized, namely in the enormous development of the seventh tergite, which is prolonged backwards over the remaining segments, so that the latter are completely concealed above and below.

Isoptera.

Two species of this order were examined, *Termopsis angusticollis* Hagen and *Leucotermes flavipes* Kollar. The former is less degenerate in the structure of the genitalia and is therefore more favorable for comparison with other groups, besides being a much larger insect; so that the following remarks, unless otherwise stated, refer to this species.

The abdomen (Figs. 60, 61), is tolerably broad and flattened, not unlike that of a cockroach in appearance, though the tergites are more uniform in size, the eighth, ninth and tenth being much abbreviated only towards the lateral margins. As in the Mantids and Blattids, the tenth tergite is prolonged over the supra-anal plate, which is obsolete in the adult; the paraprocts are broad, subtriangular and more distinctly, though not heavily, chitinized, and the short cylindrical cerci are composed of five segments, of which the apical one is much the longest and is probably compound. *Termopsis* also agrees with these two families in the concealment of the genitalia and sternal regions of segments eight and nine in a "genital cavity," under cover of the backward prolongation of the seventh sternum or "subgenital plate." As mentioned under the account of the Blattoidea, this plate is regarded by Crampton as the eighth sternum, but this is certainly erroneous. If the seventh sternum is cut away, a small chitinized flap is found, overlapping the genital orifice and also covering the bases of a pair of flattened lobes. This flap represents the free edge of the eighth sternum and the two lobes are the ventral valves. On each side of the lobes is a pair of plates, corresponding in position to the valvifers of the cockroach and, like the latter, thickened along the front margin. These plates are evidently the valvifers, the thickening representing the usual apodeme which occurs on the margin. It is not, however, continued laterad of the valvifer, there being nothing here to mark the line of junction of the eighth and ninth sterna.

Behind the overlapping by the ventral valves is a slender V-shaped sclerite. This appears to represent the vestiges of the two slender bars which meet in a similar position in *Parcoblatta* and were interpreted as the inferior apophyses of the dorsal valvulæ, meeting in the inferior intervalvula. They at least represent some part of the bases of the dorsal valvulæ

which have otherwise disappeared, together with the inner valvulæ. The remainder of the ventral surface of segments nine and ten is covered with a thinly chitinized cuticle.

In Fig. 63 the eighth abdominal spiracle may be seen in the conjunction immediately behind the eighth sternum, and close to the lateral margin, a position similar to that which it occupies in *Parcoblatta*.

It is sufficiently evident that the terminal abdominal structures of *Termopsis* are essentially like those of a Blattid in which the ovipositor has nearly disappeared. In *Leucotermes* it has quite vanished and the cerci are reduced to two segments.

Judging by the more uniform length of the abdominal tergites, the cylindrical form of the cerci, and many other characters in other regions of the body it is probable that the ancestors of the Isoptera were more primitive than any Blattoidea of recent age, but the genitalia are distinctly more suggestive of the Blattids than the Mantids, and the wing venation of the primitive New Zealand termite *Mastotermes*, is decidedly more like that of the Blattoidea than the Mantoidea or Protoblattoidea, so that I am inclined to consider the order Isoptera as an offshoot from primitive Blattoid stock.

The results of these studies of the genitalia of the Mantoidea, Blattoidea and Isoptera strongly support Crampton's grouping of these orders in a superorder "Panisoptera."

Dermaptera.

In this order the genital segments are so highly modified that they give little information that is of value in determining the systematic position of the order. While in the majority of forms the ovipositor is entirely lacking, a small one is present in some genera of Protodermaptera, notably in the families Pygidicraniidæ and Echinosomidæ (Zacher, '11),[21] so that we may conclude that the absence of this structure is a secondary condition. I have not seen any of these ovipositor-bearing forms, having, in fact, examined critically only two species of the order, viz., *Forficula auricularia* L. and *Anisolabis maritima* Bon. I have reproduced, however, figures of the ovipositor of *Kalocrania* and *Echinosoma* from Zacher (*loc. cit.*).

[21] Zacher, Friedrich, Zool. Jahrb., Bd. XXX, Syst., pp. 303–400, 80 Figs. (1911).

In *Forficula* (Figs. 62–64) the eighth, ninth and tenth abdominal tergites are fused, but their boundaries are clearly defined. The eighth and ninth tergites are very short and concealed by the much larger, overlapping seventh tergite; while the tenth is also very large, doubtless owing to the great development of the muscles concerned in the movement of the large forcipate cerci. The eighth and ninth sterna are concealed by the very large seventh sternum, and this feature, together with the reduction of segments eight and nine and the atrophy of the ovipositor is very suggestive of the "Panisoptera" (Blattoidea, Mantoidea and Isoptera); but unlike these groups, the tenth tergite does not replace the supra-anal plate, which is entirely free, and although small, is heavily chitinized and divided transversely into two separate sclerites, the distal of which is situated ventrally between the bases of the cerci, with which it is articulated. Possibly these two sclerites represent the eleventh tergite and the true supra-anal plate, as in the Acridoidea. Where three such sclerites are present (Pygidicraniidæ, Allosthetidæ, *teste* Zacher) they have been interpreted as representing the tergites of as many segments, viz., the eleventh, twelfth and thirteenth, or anal segment (pygidium, metapygidium and telson, or supra-anal plate), but the evidence for the existence of an additional segment between the eleventh and anal segments is quite insufficient. It is worthy of note, however, that these three sclerites are thus separately developed only in primitive genera.

Apart from the features mentioned above, there appears to be no evidence of close relationship between the Dermaptera and the Panisoptera.

The eighth and ninth sterna in *Forficula* are feebly chitinized and each is divided into two lateral plates, which were considered by Verhoeff ('03)[22] to represent coxites. It is probable, however, that this division of the sterna is related to the former presence of an ovipositor, which occupied the median space, and this view is supported by the presence of an ovipositor in this situation in such genera as *Kalocrania* and *Echinosoma*, as judged by Zacher's figures. In these genera the ovipositor consists of but two pairs of valvulæ, belonging to the eighth and ninth segments. The former pair is long and slender

[22] Verhoeff, H. W. Nova Acta. Acad. Caes.-Leop., Vol. XXXI, 1903, pp. 277–278.

and obviously represents the ventral valvulæ. The other pair, from its lateral position and comparatively broad form is doubtless the dorsal valvulæ. Since the dorsal valvulæ represent the coxites of segment nine, the divided sternal plates, which are also present cannot be correctly termed coxites. They are more nearly comparable to the valvifers.

In some genera, such as *Anisolabis* (Fig. 65) there is also a small paired tenth sternum, but this is absent in *Forficula*. The two large sub-triangular plates (Figs. 66, 67), which are closely united with the margins of the tenth tergite and form part of the articulation with the cerci, were regarded by Verhoeff and Zacher as the coxites of segment ten, while Crampton identified them with the paraprocts. Crampton's view is the more probable in my opinion. Coxites are absent from segment ten in all other primitive insects, so that on *a priori* grounds we should not expect to find them in the Dermaptera. Paraprocts, on the other hand, are almost invariably present, and although these plates appear to belong to segment ten, there is no reason why, in such a highly modified group as the Dermaptera, they should not have been developed from the paraprocts, as these are usually closely connected with the margins of the tenth tergite, as, e. g., in the Blattoidea.

The spiracles all occupy the pleural membrane, the last pair, as in all the groups discussed, belonging to the eighth segment.

The unsegmented form of the cerci has probably been developed within the course of evolution of the order, as in immature stages of certain primitive forms (*Diplatys*, *Karschiella* and *Bormansia*) they are segmented.

Embiidina (Embiidæ).

This small group, which is undoubtedly of ordinal rank, has been considered by some writers (Enderlein and others) to be nearly allied to the Isoptera, while others (Crampton, Westwood, MacLachlan) find closer relations with the Plecoptera and Dermaptera. The latter view, is in the present writer's opinion, much nearer the truth. The resemblance to the Isoptera is largely due to the retention in both groups of many primitive characters and to parallel development along certain lines, such as the form and venation of the wings, the two-

jointed cerci, the loss of the ovipositor, etc., but the special features of each group indicate a different line of descent.

As regards the female genitalia, but little evidence in support of either view is obtainable from this source alone. In *Embia major*, e. g., (Fig. 68) the general appearance of the terminal segments is much like that of a termite. The cerci are two-jointed as in most termites, the tenth tergite is large and curves downward, covering the supra-anal plate, to which it is adherent. On the other hand, there is no extension of the seventh sternum to form a subgenital plate, in fact, no modification of either seventh or eighth sterna, and no lateral reduction of tergites eight, nine and ten as in the Isoptera. The paraprocts are large, but unchitinized and are distinct from the well-developed cercal basipodites.

Whereas in *Termopsis* there is evidence that the Isoptera are descended from ovipositor-bearing ancestors, there is no indication in *Embia* or any of the *Embiidina* that an ovipositor was ever present, the eighth and ninth sterna being quite simple. Since an ovipositor of primitive form is present in some Apterygota (*Machilis*, *Lepisma*, etc. of the Thysanura) and is undoubtedly homologous with that of Pterygote insects, it must have been present in the earliest representations of the latter, unless we are to regard the ovipositor-bearing Thysanura as descended from winged forbears, a view which I believe few will accept. This being the case, the Embiids, Plecoptera, etc., must likewise, (contrary to Crampton's opinion) be considered as secondarily without ovipositors. The fact that *Campodea* and other *Thysanura* have also no ovipositor does not affect the question. There is evidence that some of the Palaeodictyoptera had no ovipositor, while it is certain that some of them had one, and it was probably among the former that the ancestors of the Embiids and Plecoptera existed. The ovipositor, which was probably never highly differentiated, had already disappeared before these groups had acquired independent ordinal rank.

It is scarcely profitable to make a comparison between the Embiids and Grylloblatta until the structure of the male genitalia has been considered, but the following characters held in common between the females of the two orders may be mentioned: (1) There is no reduction in the length of the eighth and ninth tergites; (2) the spiracles are all situated in the

pleural membrane; (3) neither the seventh nor the eighth sterna are prolonged into a sub-genital plate; (4) the cerci are segmented; (5) the paraprocts are feebly chitinized. The last feature has no special significance; the others indicate the primitive nature of both groups, but are otherwise negative in value, when taken alone.

No relationship to the Dermaptera or Orthoptera is even hinted at in the terminal abdominal segments of the females of Embiids.

Plecoptera.

As Crampton and others have pointed out, this order is in some respects the most primitive of existing Pterygote insects, particularly in the cervical and thoracic sclerites, wing venation and cerci. In the abdominal segments, of which ten are well developed, there is a tendency in many forms towards a considerable degree of chitinization of the pleural membrane. The ninth and tenth segments may be quite ring-like, even in the adult, while in the nymph all the segments may be annular. Crampton's suggestion that this annular form of segment may be a primitive one seems to me untenable. It is too exceptional among the Tracheata, and even within the Plecoptera there are all grades of chitinization of the pleural membrane. It is moreover, explained by the non-functional character of the abdominal spiracles in the nymph, in which respiration is performed by the tracheal gills, these structures sometimes (e. g., *Pteronarcys*) persisting in the adult in a reduced form.

The abdominal spiracles are all pleural in position, the eighth sternum is frequently more or less prolonged to form a subgenital plate, sometimes overlapping the ninth, or even the tenth, sternum. In some forms (e. g., *Megarcys signata* Hagen)[23] it is bilobed or bifid at apex, these lobes being slightly suggestive of vestigial ventral valvulæ. In most species of *Pteronarcys* there is no backward extension of the eighth sternum as a whole, but it bears a pair of slender processes, at or near the hind margin, which are probably true representatives of these valvulæ, being very similar to these structures as met

[23] Klapalek, Fr., Coll. Zool. Selys., Fasc. IV, p. 12, Fig. 6 (1912). Smith, Lucy Wright, Trans. Am. Ent. Soc., Vol. XLIII, pp. 433–489, Pls. XXIX–XXXIV (1917).

with in certain Libellulid dragonflies. There is no other trace of the ovipositor in the Plecoptera, so far as I am aware, the ninth sternum being quite simple.

The tenth segment is well developed, often little smaller than the ninth. The tergite is often somewhat prolonged behind, concealing or partly covering the small supra-anal plate, with which it may be adherent. The paraprocts are large, generally well chitinized and usually intimately fused with the bases of the cerci so that the latter appear to arise from them. The cercal basipodites are thus not distinct from the paraprocts.

The cerci are typically multiarticulate, but are very variable in respect to both the number and the form of the segments.

These characters, taken by themselves, do not throw much light on the affinities of this group, but point to a very generalized structure, with secondary loss of the ovipositor. The primitive multiarticulate cerci are approached by those of the Grylloblattoidea, more closely than any other order, with the possible exception of some of the Ephemerida.

Ephemerida.

Although the Ephemerida and Odonata can hardly be called "Orthopteroid" insects, and their lines of descent from the Paleodictyoptera are undoubtedly quite distinct from any of the others considered, they deserve a few words, on account of their having retained certain very primitive characters.

The females of Ephemerida are chiefly remarkable from the fact that the oviducts open separately, and behind the seventh, instead of the eighth sternum. In some forms the seventh sternum is prolonged backwards into a spout-like structure, which apparently functions as an ovipositor (Morrison, '19)[24] but this, of course, has no homology with any part of the Orthopterous ovipositor. The elongate, uniformly segmented abdomen, multiarticulate cerci and cerciform caudal filament, borne by the eleventh tergite are all marks of primitive structure. The anal valves are membranous and very slightly developed.

[24] Morrison, Emily Reed, Can. Ent., Vol. LI, No. 6, pp. 139–146 (1919).

Odonata.

The form of the terminal segments of the dragonflies recalls the Phasmids, as suggested by Crampton, there being no abbreviation, but on the contrary, an elongation of all of them, as compared with the usual conditions. A fully developed ovipositor is present in all of the suborder Zygoptera and some of the Anisoptera (Aeshnidæ:—Aeshninæ and Petalurinæ), while a more or less reduced and simplified one occurs in the other groups. This ovipositor is remarkable in several ways. The dorsal valvulæ are broad, subtriangular, hood-like at the apices, and form a pair of flaps or covers for the ventral and inner valves, these structures serving as the actual instrument for making the punctures or incisions in which the eggs are placed. They thus resemble closely the broad sternal processes of segment nine in *Lepisma*, *Machilis* and other Thysanura, which cover over the two pairs of valvulæ (representing the ventral and inner pairs) in quite a similar manner. They are still more interesting in the fact that they retain the styli in adult life as functional sense-organs, the Odonata being the only Pterygote order in which this is the case.

The ventral valvulæ also possess well developed basivalvulæ, the dorsal valvulæ superior and inferior apophyses. A superior intervalvula and intervalvular membrane are also present, but no inferior valvula, the strong rami of the inner valvulæ being articulated with the inferior apophysis.

There is also a valvifer, having typical connections with the valvulæ and ninth tergal apodeme.

The occurrence of these features in the Odonata is of interest in showing that they must be characters of very ancient origin and are in no way specially characteristic of Orthopteroid groups.

SUMMARY OF CHARACTERISTICS OF THE ORDERS.

Based on the Terminal Abdominal Structures of the Females of Types Examined.

Orthoptera—Eighth sternum more or less modified as a subgenital plate, but leaving ovipositor exposed; ninth sternum vertical or nearly so; valvifers (sometimes absent) in contact with ninth tergum and its marginal apodeme; ovipositor well developed (rarely vestigial or absent), with three pairs of valvulæ; basivalvulæ rarely well developed; a superior intervalvula connecting bases of dorsal valvulæ, which cover inner valvulæ and have two pairs of apophyses (superior sometimes indistinct or absent); inner valvulæ, when not vestigial, with rami, intervalvular membrane and pons, the rami with longitudinal ridge which fits into groove on ventral valvulæ; an inferior intervalvula connected separately with rami and inferior apophyses; tenth sternal region not defined, unchitinized; cerci unsegmented (two-segmented in Tridactylus); supra-anal plate well developed, sometimes fused with but not concealed by tenth tergite; paraprocts usually well developed.

Nymph: Valvulæ all slender, dorsal and ventral pairs developing from ventral surface of ninth sternum; styli rarely distinct and usually disappearing at a very early stage.

Grylloblattoidea—Eighth sternum unmodified in form, ovipositor exposed; ninth sternum, valvifers and ninth tergal apodeme as in the Orthoptera; ovipositor well developed, with three pairs of valvulæ; basivalvulæ exposed, heavily chitinized, superior intervalvula absent; dorsal valvulæ covering inner pair; both pairs of apophyses present, inferior apophyses joining one another medially, there being no separate inferior intervalvula; inner valvulæ well developed, with rami, intervalvular membrane and pons; rami fused with inferior apophyses and connected with ventral valves as in Orthoptera; tenth segment annular; cerci, slender eight-segmented; supra-anal plate small, but not concealed by tenth tergite; paraprocts not large, unchitinized.

Phasmoidea—Eighth sternum modified, usually forming a very large flap-like subgenital plate, largely concealing the ovipositor; ninth sternal regional horizontal; valvifers and

ninth tergal apodeme variable in development; ovipositor generally of considerable size, but the three pairs of valvulæ not firmly chitinized; dorsal valvulæ widely separated at base, not covering the inner pair and without a superior intervalvula; superior and inferior apophyses present, the latter widely separated; inner valvulæ united dorsal except distally and having sometimes an ineffective tongue-and-groove connection with ventral valvulæ; no intervalvular membrane or inferior intervalvula; tenth segment with distinct sternal region; cerci short, unsegmented; supra-anal plate usually small, paraprocts prominent.

Mantoidea—Tergites of segments eight and nine shortened; seventh sternum forming a very large subgenital plate concealing remaining sterna and ovipositor; eighth sternum greatly reduced; ninth, vertical or subvertical; valvifers separated from tergites, but connected across intervening membranous area by the intersegmented apodeme with eighth and ninth tergites; ovipositor of considerable size with three pairs of valvulæ, basivalvulæ heavily chitinized, widely separated, but connected by a chitinous arch or transverse bar; valvulæ of irregular form, and imperfectly chitinized; dorsal valvulæ covering inner pair, united at extreme base; superior intervalvula connecting both dorsal and inner valvulæ; dorsal valvulæ with two pairs of apophyses, the inferior apophyses joined by a large inferior intervalvula; inner valvulæ free from the latter without intervalvular membrane, but the internal (basal) prolongations of the rami connected by a thin plate which bears the median apodeme of the superior intervalvula; ventral valvulæ engaging inner by a feeble tongue-and-groove joint. Cerci subcylindrical, many-segmented; supra-anal plate vestigial, concealed by tenth tergite; paraprocts little chitinized.

Nymph (*Mantis*) similar to that of Blattoidea, but styli in last stage very minute.

Blattoidea—Abdominal segments flattened; tergites of eight and nine shortened; seventh sternum forming a very large subgenital plate, concealing remaining sterna and ovipositor; eighth sternum greatly reduced; ninth obliquely inclined; valvifers very large, separated from tergal margins, but connected across intervening membranous area with the eighth and ninth tergites by the intersegmented apodeme; ovipositor small, the three pairs of valvulæ of irregular form, more or less

imperfectly chitinized and not coherent, though an ineffective engagement between the ventral and inner valves may occur; basivalvulæ very widely separated and rotated outwards, connected in front by a chitinous arch or bar; dorsal valvulæ covering inner pair, their bases greatly expanded, and medially united; superior intervalvula connected with dorsal valvulæ and with lamella formed by united bases of inner valvulæ, which are free from ventral valvulæ and lack an intervalvular membrane; inferior apophyses represented by slender bars connected with a vestigial inferior intervalvula; cerci of moderate length, flattened, segmented; supra-anal plate absent in adult, being substituted by tenth tergite; paraprocts flattened, generally well chitinized in part.

Nymph with valvulæ terminal, dorsal pair broad and flat, retaining styli until last stage; a vestigial supra-anal plate present.

Isoptera—Abdominal segments somewhat flattened; seventh sternum forming a large subgenital plate, covering the remaining sterna; eighth sternum ill-defined and greatly reduced; ninth, oblique or almost horizontal; valvifers, when present, widely separated from tergites, the intervening space not crossed by an apodeme; ovipositor absent or represented by a very reduced pair of ventral valvulæ and traces of the bases of the dorsal valvulæ; tergites eight, nine and ten laterally narrowed, the tenth replacing the supra-anal plate, which is absent in the adult; paraprocts broad, somewhat chitinized; cerci short, slender, with 2–5 segments.

Dermaptera—Tergites of segments eight and nine greatly abbreviated and concealed by the seventh, tenth very large; seventh sternum forming a subgenital plate and concealing eighth and ninth sterna, which are medially divided; ovipositor usually absent, when present, reduced and lacking inner valvulæ; ventral valvulæ long and slender, dorsal valvulæ shorter and broader; tenth sternum sometimes represented by a pair of small sclerites; cerci very large and strong, forcipate, unsegmented (except in larvæ of some genera); supra-anal plate terminal, exposed, heavily chitinized, divided into pygidium and telson, sometimes with an intervening metapygidium; paraprocts ventral, consisting of flat, well-chitinized plates.

Embiidina—Segments seven to nine unmodified, there being no specialized subgenital plate; ovipositor wholly absent; supra-anal plate practically absent, replaced by the large tenth tergite; paraprocts lobate, unchitinized; cerci two-jointed.

Plecoptera—Eighth sternum generally more or less modified to form a subgenital plate, sometimes with a pair of lobes or processes, possibly representing vestigial ventral valvulæ; ovipositor otherwise absent; ninth sternum horizontal, unmodified; ninth and tenth segments tending to be annular; supra-anal plate variable, sometimes covered by a prolongation of the tenth tergite; cerci typically long and many-jointed, their basal segments fused with the large paraprocts.

Comparison of Ovipositors of Pterygote and Apterygote Insects.

In the Apterygota the ovipositor is present only in the families Machilidæ and Lepismatidæ of the order Thysanura. It consists of two pairs of filiform gonapophyses, arising from the eighth and ninth sternum respectively. In *Machilis* sp., e. g., the separated eighth sternum has the appearance shown in Fig. 74. It is deeply bilobed, each lobe bearing a stylus while the gonapophyses occupy a median position between the lobes. They are very long and flexible and are divided by faint constrictions with numerous segments, with regularly arranged groups of setæ. The ninth sternum (Fig. 75) is similar to the eighth, except that the styli and sternal lobes are much longer, while the gonapophyses are shorter and more slender. In the natural position they reach about the same distance back. As compared with the eighth and ninth sterna, the preceding sterna (Fig. 73) differ not only in the absence of gonapophyses, but in the union of the stylus-bearing lobes and the presence of a triangular basal plate (ste), these parts being separated only by sutures. They also differ in the presence of eversible glands (cgl).

It is now generally recognized that the basal plate is the true sternite, while the lateral styli-bearing plates are *coxites*, these probably representing flattened coxæ of abdominal limbs which have otherwise disappeared (Haase, '89).[25] The sterna of

[25] Haase, Erich, Morph. Jahrb., Vol. XV, pp. 331–435, Pls. XIV, XV (1889); Verhoeff. Zool. Anz., Vol. XXVI, pp. 60–77 (1903).

segments eight and nine in *Machilis* are thus composed chiefly of the coxites, the sternite having practically disappeared. In some of the Lepismatidæ, however, (*Nicoletia*, *Atelura*) (Escherich, '05)[26] the ninth segment has a distinct sternite overlapping the bases of the coxites just as in the thoracic segments. Comparing the eighth and ninth sterna of *Machilis* with those of the immature Blattid (Figs. 56–59) we have no difficulty in recognizing the coxites of segment nine in the flat stylus-bearing lobes, which become the dorsal valvulæ, and the gonapophyses of the same segment in the inner valvulæ of the Blattid, while the gonapophyses of segment eight in *Machilis* are the homologues of the ventral valvulæ of the Blattid. The styli of the latter segment have disappeared and the coxites are fused with the sternite, to form a "coxosternum" (Verhoeff, loc. cit.). It may be added that in *Machilis*, *Lepisma*, etc., the coxites of segment nine overlap the gonapophyses, forming a sort of sheath for them, just as they do in such Odonata as have retained a well-developed ovipositor. In *Aeshna*, e. g., (Fig. 71), the "genital valves" are the coxites of segment nine or dorsal valvulæ, and although more complex in form they have a very similar general position to those of Machilis, covering the other valvulæ in the same way, and bearing styli at their apices. There is no part of the anterior gonapophyses of *Machilis* that is distinctly recognizable as the basivalvulæ."

The homologies of the terminal abdominal structures of the female with those of the male, and other general questions will be discussed in Part II.

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[26] Escherich, K. Das System der Lepismatiden, Zoologica, Bd. 18, Heft 43, pp. 1–164, 11 Pls. and 67 text figures (1905).

EXPLANATION OF PLATES.

Reference Lettering.

ap 8, 9—apodeme of segment 8 or 9.
ar—basal arch.
bc—basipodite of cercus.
bs—basivalvula.
c—cercus.
cf—caudal filament.
clg—coxal gland
cx—coxite.
eg—egg guide.
ga—genital aperture or vulva.
hlm—internal lamella joining bases of inner valvulae.
iap—inferior apophysis.
int ap—intersegmental apodeme.
im—intervalvular membrane.
iv—inferior intervalvula.
lb—inferior lobes of inner valvulae.
p—pons valvularum.
pa—paraprocts.
pap—process of intersegmental apodeme.
pp—ventral prominence of pons.
pvd—sub-basal process of dorsal valvula.
rm—rami of inner valvulae.
sa—supra-anal plate.
sap—superior apophysis.
sp—spiracle.
spth—aperture of spermatheca.
st—sternum, sternal region.
ste—sternite.
stl—stylus.
sv—superior intervalvula.
tg—tergite.
vd—dorsal valvula.
vf—valvifer.
vi—inner valvula.
vv—ventral valvula.

Plate XX.

1. *Ceuthophilus lapidicola*, adult; lateral view of end segments and ovipositor, ventral and inner valvulae bent downwards.
2. Same, not quite mature; dorsal view of ovipositor, left ventral valvula bent outwards, right not shown.
3. Same, adult; ventral view of ovipositor.
4. Same, inner view of structures at base of ovipositor.
5. *Conocephalus fasciatus*, adult; lateral view of end segments and basal part of ovipositor.
6. Same; ventro-lateral view.
7. Same; dorsal view of superior intervalvula and basal connections of inner valvulae.
8. Same; anterior view of base of ovipositor.
9. Same; ventral view of end segments of nymph four mm. long.
10. Same; same view of nymph five mm. long.

Plate XXI.

11. *Gryllus assimilis*, adult; lateral view of end segments and base of ovipositor.
12. Same; ventro-lateral view.
13. Same; dorsal view of ovipositor, left ventral valve bent outwards, right not shown.
14. Same; inner view of structures at base of ovipositor, left side.
15. Same; anterior view of base of ovipositor.
16. *Oecanthus quadripunctatus*, adult; lateral view of end segments and base of ovipositor.
17. Same; inner view of structures at base of ovipositor, left side.
18. Same, nymph; ventral view of end segments and ovipositor.
19. *Ripipteryx forcipata* Sauss., adult; lateral view of end segments and ovipositor.
20. Same; dorsal view.
21. Same; ventral view.

Plate XXII.

22. *Melanoplus bivittatus*, adult; postero-lateral view of end segments and ovipositor.
23. Same; postero-dorso-lateral view of cleared preparation.
24. Same; posterior view of ovipositor, with valvulae forced widely open.
25. Same; ventral view of ventral valvulae.
26. *Acrydium ornatum*, adult; lateral view of end segments and ovipositor.
27. Same; dorsal view.
28. Same, nymph; lateral view.
29. Same, nymph; dorsal view.
30. Same, adult; ventral view of ventral valvulae.

PLATE XXIII.

31. *Grylloblatta campodeiformis*, adult; lateral view of end segments and ovipositor.
32. Same; ventral view.
33. Same; dorsal view of ovipositor, left ventral valvula bent outwards, right not shown.
34. Same; inner view of structure at base of ovipositor, left side.
35. Same; anterior view of base of ovipositor.
36. Same, nymph; lateral view.

PLATE XXIV.

37. *Grylloblatta campodeiformis*, nymph; ventral view of end-segments.
38. Same with ventral valvulae bent forward to expose inner valvulae.
39. *Timema californica*, adult; ventral view of end segments.
40. Same, lateral view.
41. *Diapheromera femorata*, adult; ventro-lateral view of end segments.
42. Same; lateral view of ovipositor; most of the 9th tergite cut away to show the superior apophysis.
43. Same; dorsal view of ovipositor.

PLATE XXV.

44. *Stagmomantis carolina*, adult; 8th sternum and ventral.
45. Same; dorsal view of ovipositor, with dorsal valvulae spread apart.
46. Same; ventral view of ovipositor with ventral valvulae spread apart.
47. Same; lateral view of terminal segments and ovipositor with 7th sternum bent downwards to expose the valvulae.
48. Same; inner view of structures at base of ovipositor.
49. Same; anterior view of base of ovipositor.

PLATE XXVI.

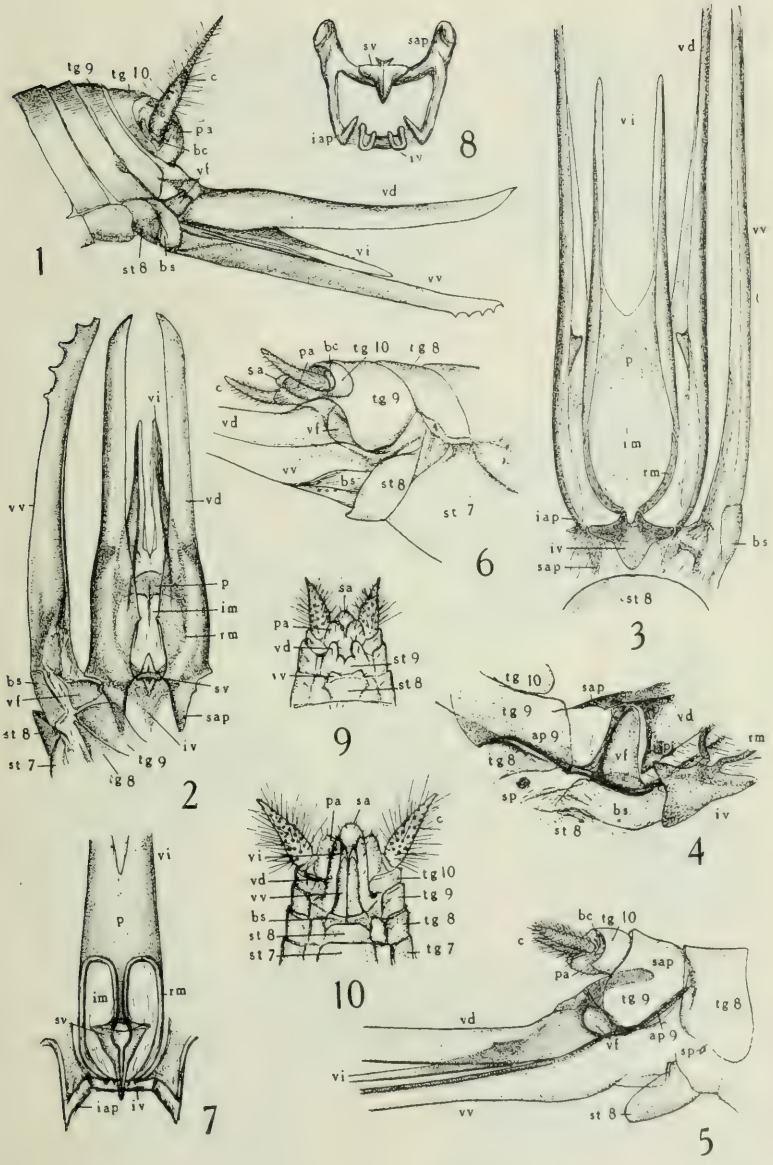
50. *Parcoblatta pensylvanica*, adult; ventral view of ovipositor, the left ventral valvula cut off at base.
51. Same; the valvulae bent forward to show their dorsal surfaces and the right dorsal valvula removed.
52. Same; ventro-lateral view of terminal segments, the 7th sternum removed.
53. Same; ovipositor removed, cleared, and viewed from above. The ventral valvulae and the dorsal valvulae, except their bases, are omitted.
54. Same, last nymphal stage; ventral view of end segments with the 7th sternum except a small part, removed.
55 to 58. Same; successive stages in the development of the genitalia, ventral view, 7th sternum removed, cerci 10th and anal segments omitted. Fig. 58 is from the adult.

PLATE XXVII.

59. *Cryptocercus punctulatus*, adult; ventral view of end segments, the 7th sternum removed.
60. *Termopsis angusticollis*, adult; lateral view of end segments.
61. Same; ventral view of end segments, the 7th sternum removed.
62. *Forficula auricularia*, adult; lateral view of end segments.
63. Same, dorsal view.
64. Same, ventral view, 7th sternum removed.
65. *Anisolabus maritima*, adult; ventral view of end segments, the 7th sternum removed.
66. *Kalocrania marmoricrura*, adult; ventral view of ovipositor and neighboring sclerites. (After Zacher.)
67. *Echinosoma occidentale*, adult; ventral view of ovipositor and part of segment 10. (After Zacher.)

PLATE XXVIII.

68. *Embia major*, adult; lateral view of end segments.
69. *Pteronarcys proteus*, adult; ventral view of end segments. (After Smith.)
70. *Perla lycorias*, adult; ventral view of end segments.
71. *Aeshna canadensis*, adult; ventral view of end segments.
72. *Machilis* sp., adult; ventral view of end segments.
73. Same; 8th sternum and gonapophyses (ventral valvulae).
74. Same; 9th sternum and gonapophyses (dorsal and inner valvulae.)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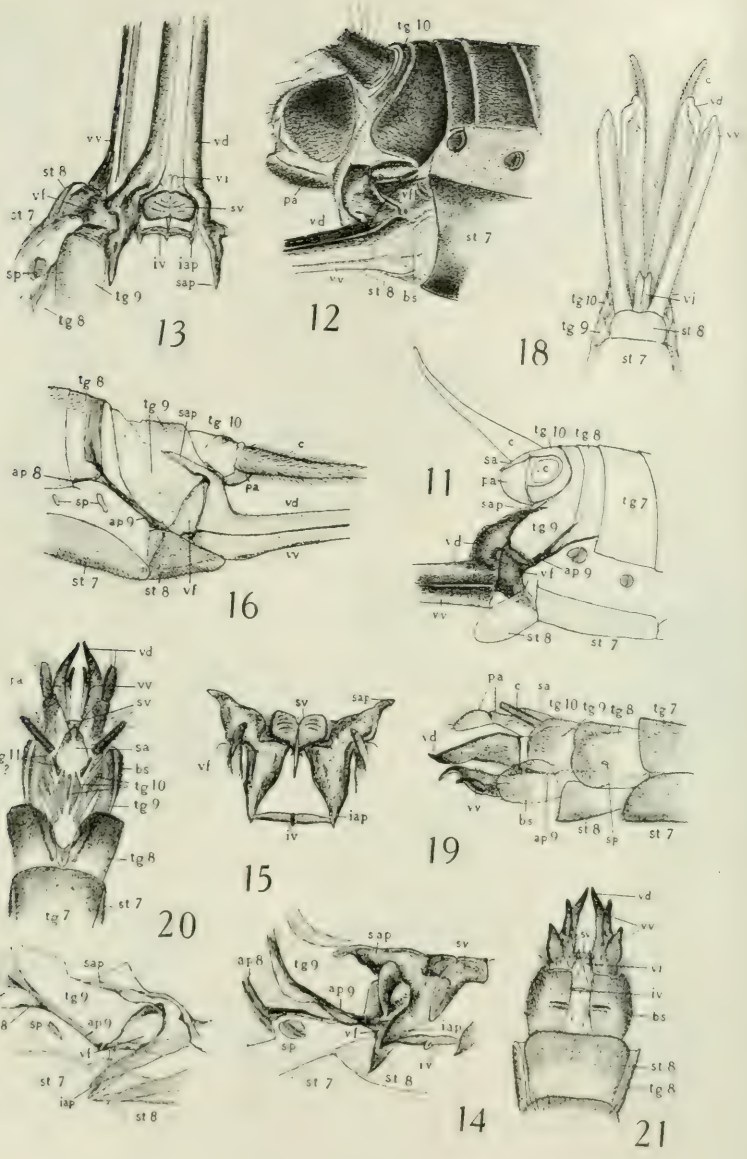
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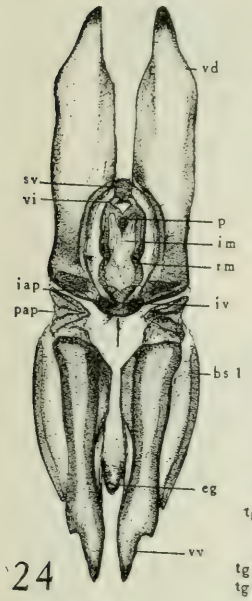

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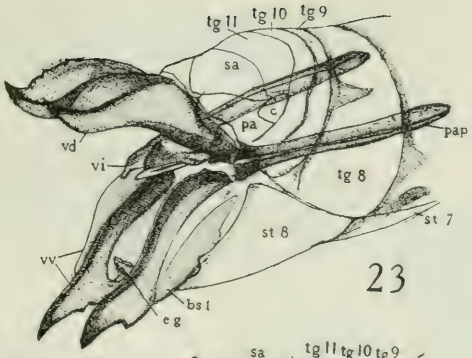

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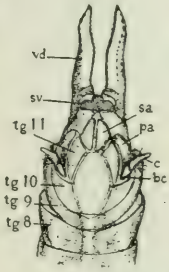

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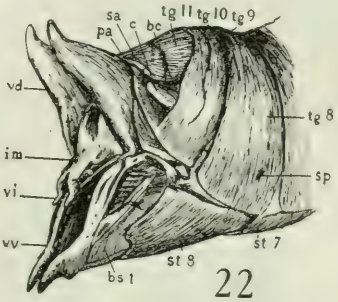

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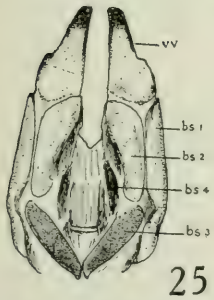

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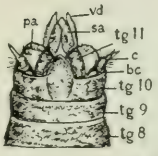

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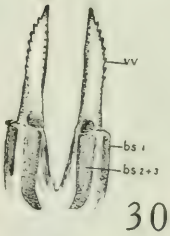

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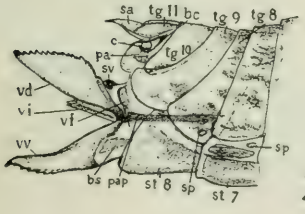

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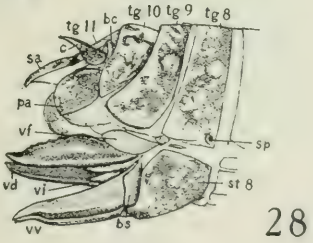

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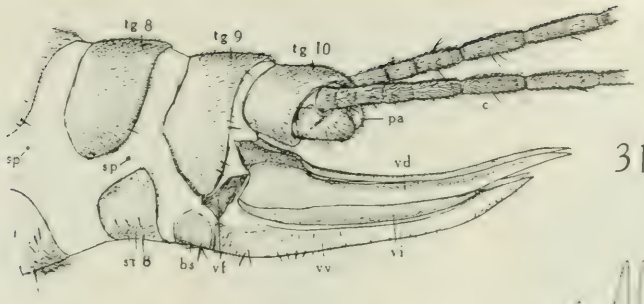

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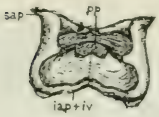

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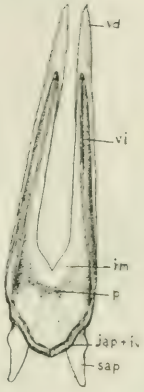

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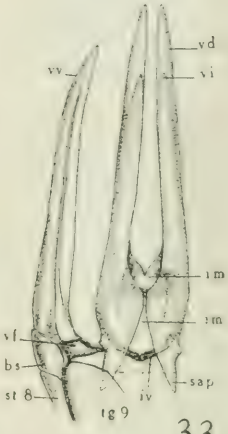

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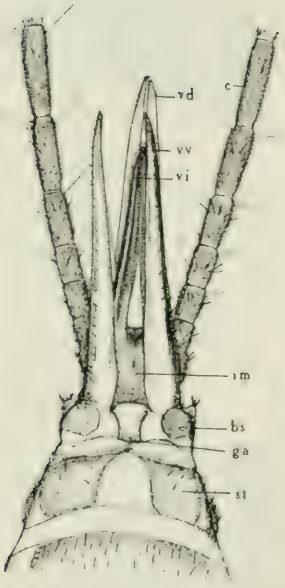

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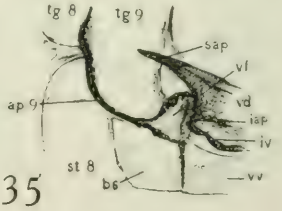

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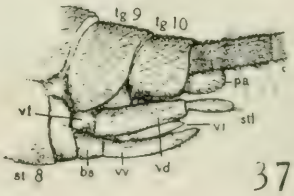

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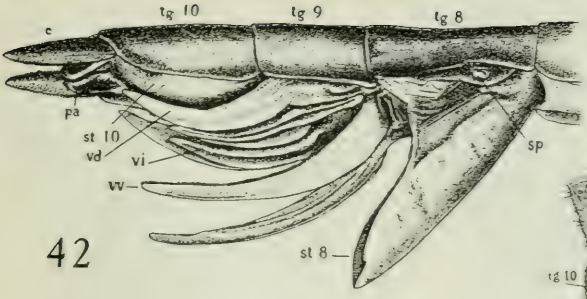

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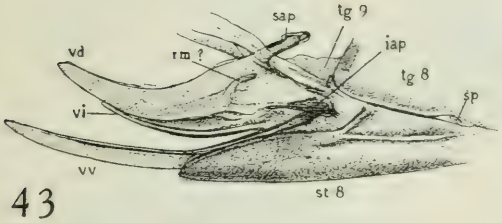

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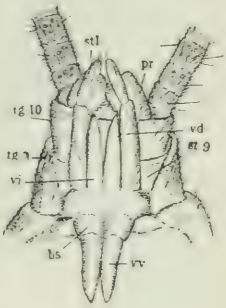

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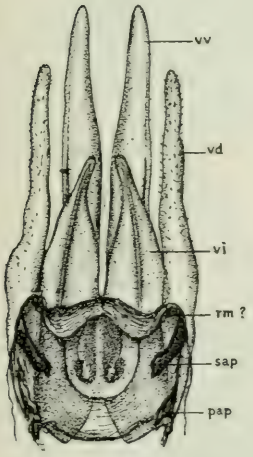

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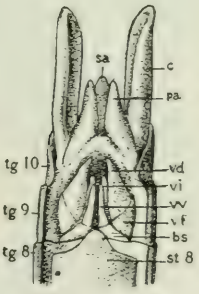

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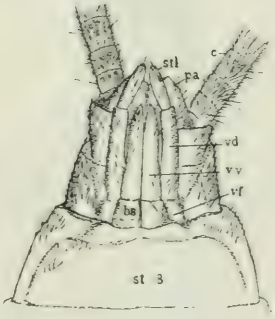

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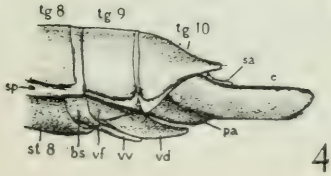

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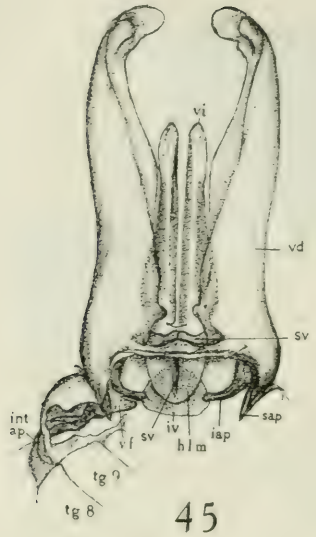

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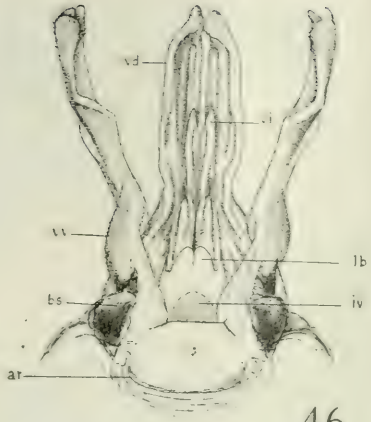

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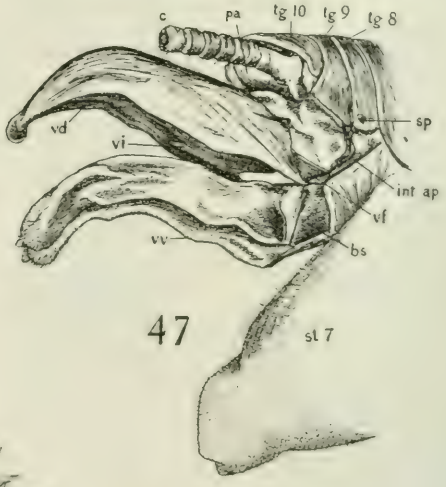

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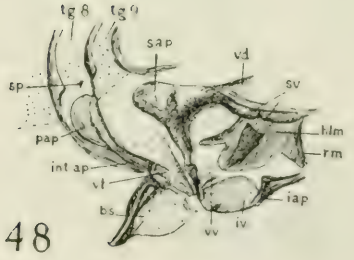

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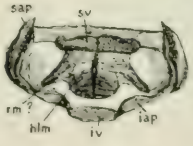

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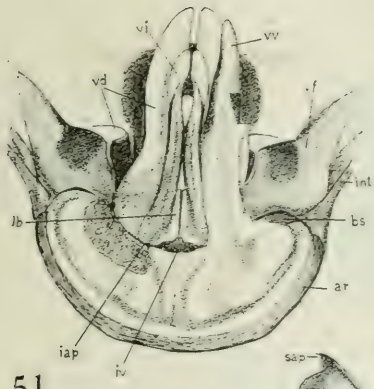

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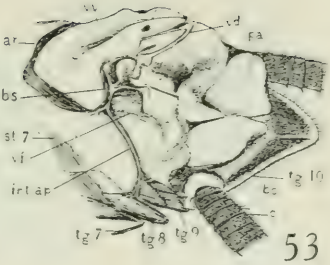

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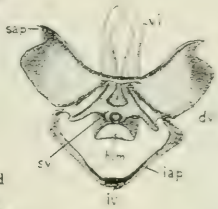

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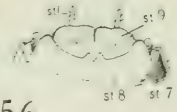

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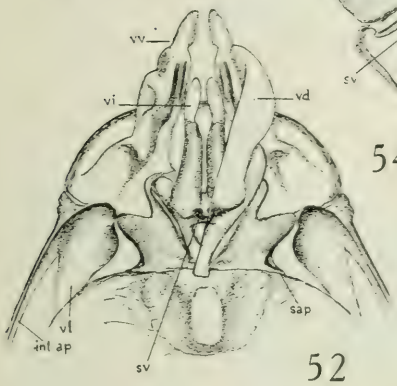

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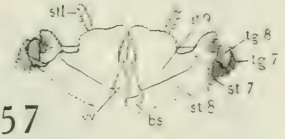

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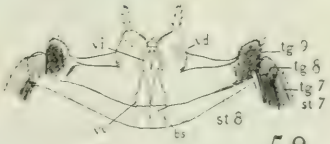

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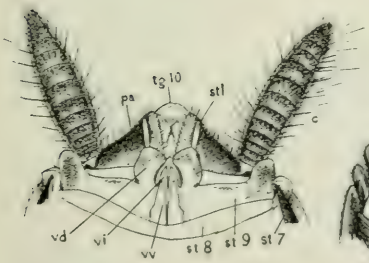

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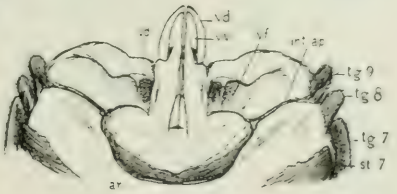

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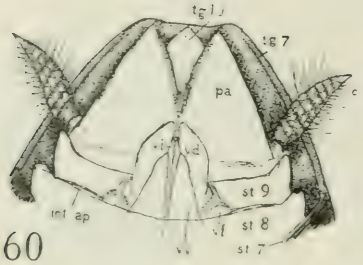

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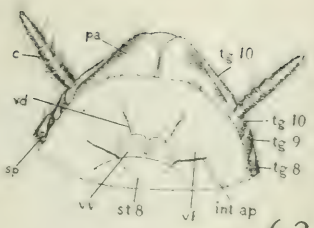

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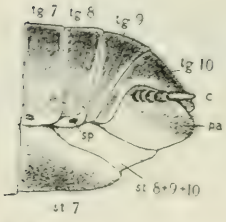

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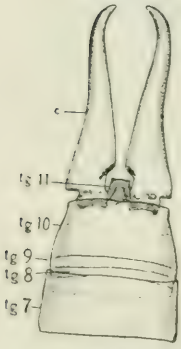

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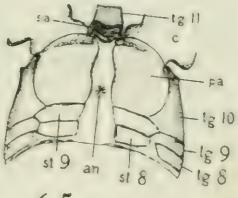

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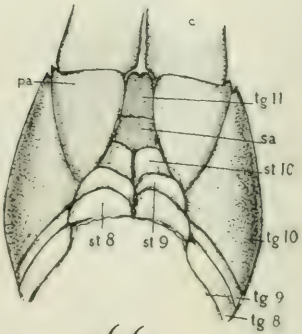

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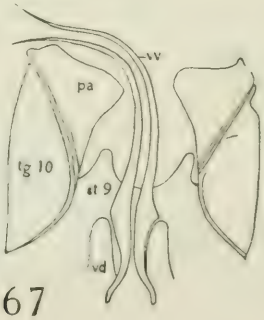

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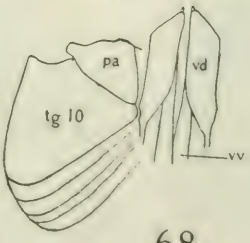

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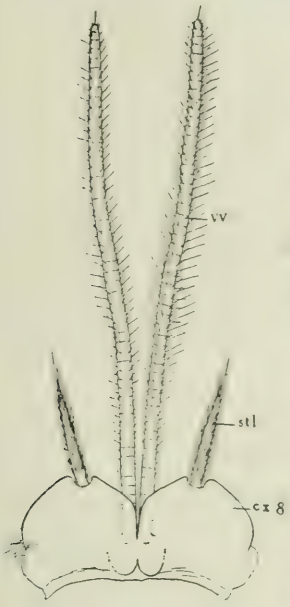

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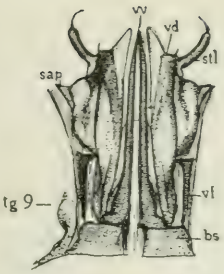

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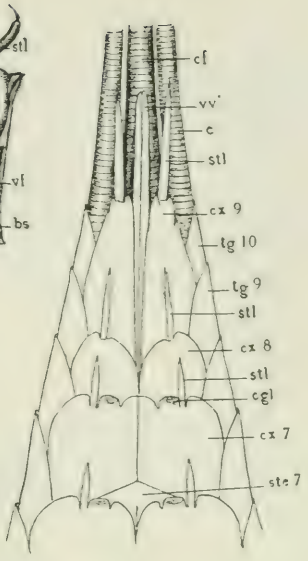

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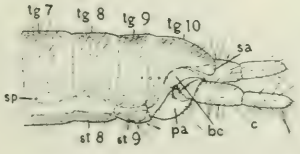

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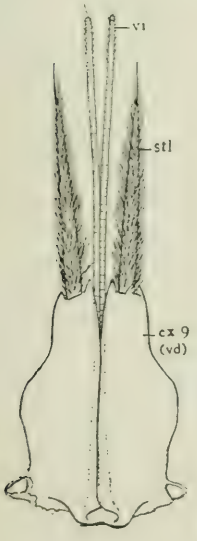

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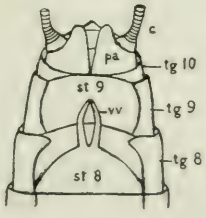

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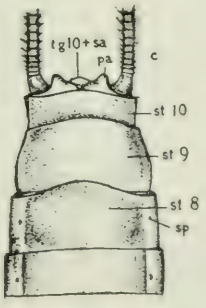

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E. M. Walker, .

UNDESCRIBED SPECIES OF JAPANESE CRANE-FLIES. (TIPULIDÆ, DIPTERA)

By Charles P. Alexander, Ph. D.

The species of crane-flies herein described as new were included in some extensive and highly interesting collections made in the vicinity of Tokio by Mr. Ryoichi Takahashi, during the years 1918 and 1919. The station "Saitama," refers to Chichibu, in the province of Saitama, a mountainous locality about fifty miles from Tokio. The types are preserved in the collection of the author. I am greatly indebted to Mr. Takahashi for this very valuable series of Japanese Tipulidæ.

Dicranomyia Stephens.

Dicranomyia immodestoides sp. n.

Resembles *D. immodesta* O. S. (Eastern North America); antennæ dark brown throughout; general coloration light gray; wings nearly hyaline, stigma pale; veins Sc_1 very long, abdomen dark brown, indistinctly ringed with yellow.

Male—Length, 5.8 mm.; wing, 6.6 mm.

Female—Length, 6.8 mm.; wing, 7.4–8.3 mm.

Rostrum reddish brown; palpi dark brown. Antennæ with the scape brownish black, the basal flagellar segments brown, the apical segments darker. Head light yellowish gray; the front and the vertex adjoining the inner margin of the eyes bright silvery.

Mesonotum dull gray, the praescutum with an indistinct median brown stripe; lateral stripes indistinct; humeral areas a little more reddish; scutum reddish gray, the lobes largely brown; scutellum reddish gray; postnotum gray. Pleura light gray, indistinctly marked with darker beneath the wing root. Halteres rather long, pale, the knobs dark brown, the base of the stem more yellowish. Legs with the coxæ and trochanters yellow, the former very sparsely gray pruinose, the fore coxæ dark basally; femora dull brownish yellow, somewhat darkened on the apical half; tibiæ and tarsi brown. Wings nearly hyaline, the stigma large, oval, very pale brown; veins slender, brown. Venation: Sc_1 ending opposite origin of Rs, Sc_2 far before the tip of Sc_1, the latter being longer than the basal deflection of Cu_1; r arcuated, at the tip of R_1; cell *1st* M_2 open by the atrophy of m; basal deflection of Cu_1 at or before the fork of M.

Abdominal tergites dark brown, the segments laterally at the base and on the caudal margin dull yellow; sternites nearly similar, the bases of the segments likewise yellowish. In the female the bicolored

condition of the abdomen is not so evident as in the male. Male hypopygium with the ninth tergite deeply notched medially, the adjacent lobes evenly rounded, setigerous; dorsal pleural hook moderately long, at the tip suddenly narrowed into a slender point; ventral pleural appendage large, fleshy, the proximal basal portion produced into a fleshy lobe that bears two erect chitinized spines on its caudal face.

Habitat: Japan.
Holotype, ♂, Meguro, Tokio, April 1, 1919 (R. Takahashi).
Allotopotype, ♀, March 31, 1919.
Paratopotypes, 6 ♂ ♀'s, March 25–May 26, 1919.

Dicranomyia basifusca sp. n.

Antennæ black throughout; thorax gray, the praescutum with an indistinct median brown stripe; wings pale gray, the stigma and a rounded spot at the base, brown; *Sc* ending a little beyond the origin of *Rs*, cell *1st* M_2 closed.

Female—Length, 4.8 mm.; wing, 6.4 mm.

Rostrum and palpi dark brownish black. Antennæ black throughout, the basal flagellar segments short-oval, the terminal segments a little more elongated. Head gray, the front more tawny.

Mesonotum dull gray, the praescutum more brownish medially to form an indistinct dorsal stripe; scutellum and postnotum lighter gray. Pleura dark gray. Halteres yellow, the knobs dark brown. Legs with the coxæ brownish yellow, darker basally; trochanters dull yellow; femora dull brownish yellow, darkened toward the apices, the extreme tips pale; tibiæ yellowish brown, the tips narrowly darker brown; tarsi dark brown. Wings with a faint grayish tinge, the stigma short-oval, brown; a conspicuous rounded brown spot at the arculus; origin of *Rs* and the cord very indistinctly seamed with darker. Venation: Sc_1 ending slightly beyond, Sc_2 exactly opposite, the origin of *Rs;* *Rs* angulated to almost square at origin; cell *1st* M_2 long, closed, about equal in length to the veins issuing from it; basal deflection of Cu_1 at the fork of *M*.

Abdomen dark brown. Ovipositor reddish, the tergal valves very slender.

Habitat: Japan.
Holotype, ♀, Meguro, Tokio, April 10, 1919 (R. Takahashi).

Dicranomyia atripleura sp. n.

Head light grey; mesonotum brownish grey, the praescutum with three pale brown stripes; thoracic pleura with a dark brown longitudinal stripe; legs pale brown; wings greyish subhyaline, stigma rounded, brown; *Sc* short, cell *1st* M_2 closed, about twice as long as vein Cu_1 beyond it.

Female—Length about 6.3 mm.; wing, 6.5 mm.

Rostrum and palpi brown. Antennæ with the scapal segments pale brown; flagellum broken. Head light grey.

Pronotum brownish grey. Mesonotal praescutum pale brownish grey, with three pale brown stripes, the median stripe broad, the lateral stripes indistinct; scutum pale, the lobes darker; scutellum and postnotum heavily light grey pruinose, the latter with a darker median line. Pleura pale, yellowish grey pruinose; a broad, very conspicuous, dark brown stripe, extending from the propleura to the base of the abdomen, passing above the fore coxæ and beneath the halteres. Halteres pale yellow basally, the knobs dark brown. Legs with the coxæ and trochanters pale yellow; femora and tibiæ pale brown; tarsi darker brown. Wings greyish subhyaline; stigma rounded, brown; veins dark brown, *C*, *Sc* and the veins at the wing-base more yellowish. Venation: *Sc* short, Sc_1 ending a little beyond the origin of *Rs*, Sc_2 exactly at the origin; *Rs* less than twice the deflection of R_{4+5}; *r-m* about equal to *m*, a little shorter than *r;* cell *1st* M_2 long, about twice the section of Cu_1 beyond it; basal deflection of Cu_1 immediately before the fork of *M*.

Abdomen dark brown, the sternites more yellowish brown. Ovipositor with the tergal valves slender, strongly upcurved; sternal valves straight, the tips subacute.

Habitat: Japan.

Holotype, ♀, Choshi, Chiba, October 17, 1919, (R. Takahashi).

Dicranomyia mesosternata sp. n.

Antennæ dark brown; head dark; mesonotum brownish black, the pleura gray pruinose; wings pale gray with four brown costal marks and pale gray clouds along the cord and at the ends of the veins; Sc_2 apparently lacking.

Female—Length, 7.3–8 mm.; wing, 8–8.4 mm.

Rostrum and palpi dark brown. Antennæ dark brownish black throughout, the flagellar segments elongate-oval, with rather long verticils. Head dark brownish gray. Vertex very narrow between the large eyes.

Pronotum conspicuous, brown, narrowed anteriorly. Mesonotal praescutum shiny brownish black, the humeral regions with a paler brown pollen; remainder of the mesonotum brown, the scutal lobes brownish black. Pleura shiny dark brownish black, light gray pruinose, most heavily across the dorsal edge of the mesosternum, which is shiny blackish between the fore and middle coxæ. Halteres with the base of the stem pale, the knobs dark brown. Legs with the coxæ yellowish brown, darkest on the fore coxæ; trochanters dull yellow; femora brown, paler basally, the tips dark brown; tibiæ and tarsi dark brown. Wings pale gray, with a heavy dark brown and brownish gray pattern, as follows: four large brown areas along the costal margin, the first at

the arculus, the third at the tip of Sc_1 and the origin of *Rs*, the last being the stigmal blotch; wing-apex darkened; large, pale brownish gray clouds along the cord, outer end of cell *1st* M_2 and at the ends of the longitudinal veins; veins dark brown. Venation: *Sc* short, Sc_1 ending opposite or slightly beyond the origin of *Rs*, Sc_2 lacking; a supernumerary cross-vein at about midlength of cell *Sc*, located in the second anterior brown blotch; *Rs* about two and one-half times as long as the basal deflection of R_{4+5}; cell *1st* M_2 closed; basal deflection of Cu_1, before, at or slightly beyond the fork of *M*.

Abdominal tergites dark brown, the sternites paler brown. Male hypopygium with the ninth tergite broad, the caudal margin gently concave. Ninth pleurite short; ventral pleural appendage pale, the proximal face produced into a stout beak, set with two widely separated spines, one subapical, the other basal. Gonapophyses a little longer than half the length of the penis-guard, slender and gently curved.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, October 20, 1919, (R. Takahashi).

Allotopotype, ♀, July 9, 1919.

Paratopotypes, 4 ♂'s, October 20–21, 1919; 1 ♀, 1 sex uncertain, July 12, 1919.

One paratype bears the label, "This insect was flying about over a stream."

Antocha Osten Sacken.

Proantocha, subgen. n.

Antennæ short, the flagellar segments oval, the terminal segment nearly as long as the preceding two taken together. Head very small, broad, the small eyes protuberant, widely separated both above and below. Thorax very large, the mesonotum convex. Halteres short. Legs very stout, the fore and middle legs covered with conspicuous long erect hairs, the posterior tibiæ with numerous tiny black spines; the coxæ, especially the posterior ones, very large and globular, the hind trochanters being long, narrow, compressed; hind legs very long, especially the tibia, which is slightly curved before its tip; at the base on the ventral face a long, slender spine which meets a similar but stouter tubercle located near the apex of the femur; tarsi remarkably shortened, especially those of the hind legs where they are less than one-fourth the length of the tibia; claws long and straight, at about mid-length with a long straight tooth that is about two-fifths the length of the apex of the claw alone, an additional tiny basal tooth. Venation as in the subgenus *Antocha*. Abdomen short.

Type of the subgenus—*Antocha* (*Proantocha*) *spinifer* sp. n. (Japan).

The genus *Antocha* has, till now, been one of the most compact genera in the Tipulidæ. The discovery of *Antocha spinifer* renders it necessary to subdivide the group. This latter is a curious fly with long, stout, very hairy legs that suggests in its general appearance a *Trimicra* or an *Empedomorpha* rather than an *Antocha*. The venation alone is normal for this latter genus. The discovery of the immature stages of this isolated, generalized fly will possibly result in giving generic rank to the group here proposed.

Antocha (Proantocha) **spinifer** sp. n.

Size very large (wing of male over 12 mm.); legs very long and stout, the fore and middle legs provided with long, dense hairs, the hind tibiæ set with numerous tiny spines and with a large spinous tubercle on the ventral side near the base.

Male—Length about 9 mm.; wing, 12.3 mm. Fore leg, tibia, 7.8 mm.; tarsus, 4.8 mm.; middle leg, tibia, 7.4 mm., tarsus, 3 mm.; hind leg, tibia, 13.8 mm., tarsus, 3 mm.

Rostrum short, dull yellow; palpi short, brownish yellow, the terminal segments more infuscated. Antennæ with the scape and basal three or four segments of the flagellum dull brownish yellow, the remainder of the antennæ brown. Head dull yellow, very sparsely light gray pruinose.

Mesonotum dull brownish yellow, the praescutum darker brown medially, the lateral margins pale. Pleura dull yellow. Halteres pale, the knobs slightly brownish. Legs with the coxæ and trochanters dull yellow; remainder of the legs dull brownish yellow, only the terminal tarsal segments brown; the long, dense hairs that cover the fore and middle legs are dark brown and obscure the ground color of the sclerites that bear them. The hind legs are covered with numerous blackened spinous setigerous tubercles. Claws very long, dark brown, longer than the fourth and nearly as long as the fifth tarsal segment. Wings milky white, stigma indistinct, faintly yellowish; veins brown, the costa beyond the point of insertion of *Sc* tawny and somewhat incrassated. Venation: *r* tending to be obliterated by atrophy; basal deflection of Cu_1 far before the fork of *M*.

Abdominal tergites brownish buff, with a distinct dark brown median stripe that is interrupted at the posterior margins of the segments; sternites reddish, on the terminal segments darker, brownish, the caudal margin of the segments broadly pale.

Habitat: Japan.

Holotype, ♂, Saitama, June 1, 1919 (R. Takahashi).

Antocha (Antocha) **satsuma** sp. n.

Head rusty brown; thorax gray, the praescutum with three brown stripes; wings milky gray, the stigma dark brown; veins *Sc*, R_1 and *C* beyond the stigma chestnut brown; basal deflection of Cu_1 before the fork of *M*.

Male—Length, 5.3–5.5 mm.; wing, 7.3–7.6 mm.

Female—Length, 6.8 mm.; wing, 8 mm.

Rostrum pale reddish brown; palpi dark brown. Antennæ brown, the flagellar segments a little paler basally; scapal segments large, tumid. Head pale rusty brown, with a faint bronzy tinge.

Pronotum grayish yellow, broadly dark brown medially. Mesonotal praescutum grayish yellow with three broad dark brown stripes, the median stripe broadest, not attaining the anterior margin of the sclerite; scutum gray, the lobes dark brown medially; scutellum and postnotum gray. Pleura yellowish gray. Halteres very pale yellow. Legs long and slender, the coxæ pale, sparsely gray pruinose; trochanters dull yellow; femora pale brown, more yellowish basally; tibiæ and tarsi pale brown. Wings milky gray, pale at the base, the stigma dark brown; slightly darker clouds along veins *Rs* and *2nd A* and at the wing apex; veins dark brownish black, *M* and *Rs* pale basally; *Sc*, R_1 and costa beyond Sc_1 light chestnut brown. Venation: *Rs* long and straight, the base rather indistinct; *r* opposite *r–m;* basal deflection of Cu_1 far before the fork of *M*, this distance variable; cell *1st* M_2 small.

Abdomen dark brownish gray, the sternites paler medially, in the female the posterior half of the intermediate abdominal segments is slightly paler than the basal half. Male hypopygium yellowish, the pleurites rather stout; the two pleural appendages are slender, subequal in length, the dorsal hook chitinized, at the tip narrowed into a slender point; ventral pleural appendage fleshy with scattered setæ that are larger and stouter at the tip of the organ. Gonapophyses long, acicular, almost straight, the tips acute.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, April 21, 1919 (R. Takahashi).

Allotopotype, ♀, March 25, 1919.

Paratopotype, 2 ♂'s, March 26–April 23, 1919.

Dicranoptycha Osten Sacken.

Dicranoptycha yamata sp. n.

Antennæ black, the scapal segments dull yellow; general coloration gray, the praescutum with three brownish stripes; legs black, the bases of the femora narrowly yellowish; abdomen dark brownish black.

Female—Length about 11 mm.; wing, 12.7 mm.

Rostrum and palpi black. Antennæ with the scapal segments dull brownish yellow, the second segment brightest; flagellum black, the base of the first segment paler. Head light gray.

Pronotum brownish gray. Mesonotal praescutum dull gray, clearer anteriorly, with three slightly darker brownish stripes; remainder of the mesonotum clear light gray, only the scutal lobes a little darker. Pleura gray. Halteres yellow. Legs with the coxæ grayish, the mesocoxæ more yellowish; trochanters yellow; femora dark brownish black, the bases narrowly yellow; remainder of the legs dark brownish black. Wings with a strong grayish yellow tinge, somewhat darker distally, the costal and subcostal cells clearer yellow; veins *C* and *Sc* yellow, the remaining veins dark brown. Venation: *Rs* strongly arcuated at its origin, a little longer than cell *1st* M_2.

Abdomen dark brownish black. Ovipositor with the tergal valves flattened, the outer faces with numerous erect yellow setæ.

Habitat: Japan.

Holotype, ♀, Meguro, Tokio, April 23, 1919 (R. Takahashi).

Paratopotypes, 2 ♀, April 24–May 5, 1919.

One specimen bears the label "in a pine forest."

Paratropeza Schiner.

Paratropeza flavitibia sp. n.

General coloration metallic blue; legs yellow, the femora clavate, with a broad black subterminal ring; tibiæ with the tips blackened, the posterior tibiæ with an apical fringe of erect black hairs; metatarsi yellow, darkened at the tips; wings with three broad dark brown cross-bands.

Female—Length, 6.3 mm.; wing, 4.7 mm. Fore leg, femur, 2.9 mm.; tibia, 2.6 mm.; hind leg, femur, 4 mm.; tibia, 3.3. mm.; tarsus, 2.4 mm.

Description from an alcoholic specimen.

Rostrum and palpi pale brown, the terminal segments of the latter about one-half longer than the third segment. Antennæ brown, the second scapal segment and the base of the first flagellar segment more yellowish; flagellar segments oval. Head dark metallic blue.

Thorax metallic blue, with only the dorso-pleural membranes whitish. Halteres dark brown, the knobs whitish. Legs with the coxæ metallic blue on their outer faces; trochanters yellowish brown; fore femora dark brown, more yellowish on the basal half, the extreme tip and a very indistinct band at about one-third the length dull yellowish; middle and posterior femora yellow with a broad dark brown subterminal ring; tibiæ yellow, more brownish basally, the tips broadly dark brownish black, broadest on the hind legs; metatarsi yellow, only the tips brown; remaining tarsal segments dark brown; on the posterior metatarsi the brown tips occupy one-third of the total length. The legs are provided with flattened scales; the femora are strongly clubbed, especially the posterior femora; the posterior tibiæ with a broad apical fringe of outspreading black hairs. Wings hyaline, with three broad brown cross bands, the first proximad of the origin of the sector, extending from the costal to the posterior margin; the second band occupies

the cord; the third the wing apex; costal and subcostal cells brownish yellow; a small brownish spot at the origin of the sector, sometimes confluent with the basal crossband. Venation: almost exactly as in *P. ornatipennis* (de Meij.); *Sc* short, Sc_1 extending to about two-fifths the length of *Rs*, Sc_2 being proximad of the origin of the latter.

Abdomen dark metallic blue; ovipositor yellowish corn color, the sternal valves darker; tergal valves strongly curved.

Habitat: Japan:

Holotype, ♀, Chichibu, Province Saitama, October, 1918 (R. Takahashi).

Edwards (Ann. Mag. Nat. Hist., ser. 8, vol. 17, p. 356; vol. 18, p. 249; 1916) records this new species from Idzu, Japan (June, 1910), but does not give it a name. *P. flavitibia* is closest to *P. ornatipennis* (de Meij.) but is sufficiently distinguished by the broad complete basal wing band and the different leg pattern. The brush of erect or nearly erect hairs at the tips of the posterior tibiæ is very conspicuous and suggests the condition found in the recently described *P. pennipes* (Brunetti) of India (Records Indian Mus., vol. 15, p. 308, 1918; as *gymnastes*). This fly differs from *flavitibia* in the pattern of the legs and wings.

Ormosia Rondani.

Ormosia diversipes sp. n.

Belongs to the *nigripila* group; general coloration black, including the femora, the tibiæ and tarsi abruptly light yellow; wings gray, the stigma brown, the costal margin with yellowish pubescence; anal veins divergent.

Male—Length, 4–4.3 mm.; wing, 5.1–5.5 mm.

Rostrum and palpi dark brownish black. Antennæ with the basal four or five segments yellowish brown; remainder of the flagellum dark brown; flagellar segments (in the male sex) elongate-cylindrical, with abundant erect whitish pubescence that is little shorter than the length of the segment that bears it. Head dark.

Pronotal scutellum pale. Mesonotal praescutum blackish with a heavy reddish brown pollen, the dorso-median area darker, producing an indistinct stripe. Pleura shiny blackish; a brush of more than a score of long erect yellowish hairs on the pleura between the bases of the wings and halteres. Halteres light yellow. Legs with the coxæ dark brownish black, sparsely pruinose; trochanters dull yellowish brown; femora black, a little lighter basally; tibiæ and metatarsi abruptly light yellow, the tips narrowly darkened; remainder of the tarsi dark brown. Wings gray, the stigma more brownish, the costal region more yellowish; base of the wing and an indistinct area near the fork

of *M* pale; veins brown; wings broad, densely covered with hairs. Venation: Cell *1st* M_2 small, closed; basal deflection of Cu_1 slightly before the fork of *M;* anal veins strongly divergent.

Abdomen black. Hypopygium of the general structure of the *nigripila* group of the genus; pleurites stout, one pleural appendage much longer than the others, dusky in color, tapering gradually to the acute tip; the second appendage is shorter, flattened, subhyaline. The gonapophyses are flattened blades, deeply bifid apically with the proximal arm about twice the length of the outer arm.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, March 31, 1919 (R. Takahashi).

Paratopotypes, 1 ♂, March 26; 2 ♂'s, April 16, 1919.

Ormosia atripes sp. n.

Belongs to the *nigripila* group; general coloration black, including the legs; wings grayish brown; anal veins divergent.

Female—Length 5–5.3 mm.; wing, 5.8–5.9 mm.

Rostrum and palpi dark brownish black. Antennæ with the first scapal segment brown, second segment large, broadly pyriform, light yellow; flagellum dark brownish black, the segments oval (in the female sex). Head dark.

Sides of the pronotal scutellum yellowish white. Mesothorax blackish with a sparse dull yellowish brown pollen; scutellum with long coarse yellow bristles. Pleura black, a sparse group of from six to eight long erect yellowish hairs between the bases of the wings and halteres. Halteres light yellow. Legs with the coxæ brownish black; trochanters yellowish brown, brighter basally; femora dark brownish black, paler basally; remainder of the legs brownish black. Wings with a dark grayish brown suffusion, brighter basally and in the costal region; stigma indistinct, brown; a faint whitish spot beyond the stigma and a larger, somewhat more distinct, one at the fork of *M;* veins dark brown, *R* and *Cu* yellowish; wings broad with a dense delicate pubescence. Venation: *r* just beyond the fork of R_{2+3} on R_2; cell *1st* M_2 small, closed, the inner end narrowed, the outer deflection of M_3 a little longer than *m;* basal deflection of Cu_1 at or slightly before the fork of *M;* anal veins strongly divergent.

Abdomen black; tergal valves of the ovipositor strongly curved, black basally, dark horn yellow apically; sternal valves dark, the tips acute.

Habitat: Japan.

Holotype, ♀, Meguro, Tokio, April 10, 1919 (R. Takahashi).

Paratopotypes, 7 ♀'s, April 9–25, 1919.

Ormosia tokionis sp. n.

Belongs to the *fascipennis* group; general coloration gray; femora yellowish at the base; wings pale gray with a narrow pale brown seam along the cord.

Male—Length, about 3.8 mm.; wing, 5.2 mm.

Female—Length, about 4.5 mm.; wing, 6.1 mm.

Rostrum dark with a gray pollen. Palpi dark brown. Antennæ dark brown, short in both sexes, the flagellar segments oval in the male, clothed with a dense white pubescence. Head grayish brown, a little clearer brown along the margin of the eyes.

Mesonotal praescutum yellowish gray with four indistinct reddish brown stripes; tuberculate pits a little anterior to the level of the pseudosutural foveæ, separated from one another by a distance equal to, or a little less than, the diameter of one; scutellum and median area of the scutum lighter; postnotum gray. Pleura gray. Halteres rather long, dark brown, the base of the stem yellowish. Legs with the coxæ dark, covered with a yellowish gray pollen; trochanters dull brownish yellow; femora brown, the bases more yellowish, darker brown at the tips; tibiæ and tarsi brownish black. Wings pale gray, the veins narrowly and indistinctly seamed with brownish, more distinct along the cord; stigma large, brown; costal and subcostal cells a little more yellowish; veins dark brown. Venation: *r* on R_2, about its own length beyond the fork of R_{2+3}; deflection of R_{4+5} longer than *r-m;* cell *1st* M_2 closed; basal deflection of Cu_1 beyond the fork of *M;* anal veins divergent.

Abdomen dark brown. Male hypopygium small, the pleurites rather slender, nearly cylindrical; a single pleural appendage that is narrowed to the blunt, blackened apex, the surface with abundant setigerous punctures. Penis-guard a narrow, triangular chitinous plate, which has a narrow median apical point.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, March 23, 1919 (R. Takahashi).

Allotopotype, ♀, March 23, 1919.

Paratopotype, ♂, March 25, 1919.

Ormosia cinctifer sp. n.

Belongs to the *fascipennis* group; general coloration black, the body sparsely dusted with gray; wings nearly hyaline, a narrow brown seam along the cord.

Male—Length, 4.5–4.7 mm.; wing, 6.4–6.5 mm.

Female—Length, 5.6–5.8 mm.; wing, 6.3–7 mm.

Rostrum and palpi black. Antennæ black, short in both sexes, in the male the intermediate segments rounded oval, the apical segments long-oval. Head dark gray with a sparse brownish yellow pollen.

Mesonotal praescutum black, sparsely dusted with gray, with three blackish stripes, the median one shiny, the lateral stripes less distinct;

scutum similar, each lobe with a long-oval blackish area; scutellum and postnotum black, sparsely gray pruinose. Pleura black, gray pruinose. Halteres light yellow, the base of the stem dusky. Legs black. Wings nearly hyaline; stigma dark brown, conspicuous, sending a narrow brown seam along the cord; outer end of cell *1st* M_2 and vein *Cu* less distinctly seamed with brown; veins dark brown; the base of the wing more yellowish; wings with the pubescence rather short and sparse, almost lacking in the basal cells, including most of cell *M*. Venation: Sc_1 ending just beyond *r; r* on R_2 near its base; cell *1st* M_2 closed; *m* shorter than the deflection of M_3; basal deflection of Cu_1 slightly before the fork of *M; 2nd anal* vein slightly sinuous, but cell *1st A* broadest at the wing margin.

Abdomen black, including the male genitalia. Male hypopygium with the pleurites stout; pleural appendage oval, tumid, with long yellowish hairs, on the dorsal face with a chitinized plate, each side of which is heavily toothed, the outer margin with from five to six teeth and the inner margin with about three teeth; gonapophyses flattened, slender, tapering to the subacute tips. Ovipositor with the tergal valves horn color, darker basally.

Habitat: Japan.
Holotype, ♂, Meguro, Tokio, April 2, 1919 (R. Takahashi).
Allotopotype, ♀, April 2, 1919.
Paratopotypes, 2 ♂'s, 1 ♀, March 25–April 10, 1919.

Ormosia takahashii sp. n.

Belongs to the *varia* group; general coloration black, gray pruinose; wings grayish with the stigma brown; cell *1st* M_2 open; anal veins convergent; male hypopygium with eight chitinized points surrounding the penis-guard.

Male—Length, 3.8–4.2 mm.; wing, 5.4–5.5 mm.

Female—Length, 4.6 mm.; wing, 6.2 mm.

Rostrum and palpi dark brown. Antennæ brown, the flagellar segments long-oval, covered with a dense white pubescence, the flagellum with a single very long verticil before midlength of each segment to give the organ a secund appearance. Head dull gray.

Mesonotum dull brownish gray, the praescutum with indistinct, somewhat darker brown stripes, the interspaces with a row of coarse yellowish hairs; tuberculate pits very close together. Scutum dull gray, the lobes darker. Pleura black, sparsely gray pruinose; a few very long yellow hairs ventrad and caudad of the wing-base. Halteres yellow. Legs with the coxæ dark, sparsely gray pruinose; trochanters dull yellow; femora dark brown, the bases yellow; tibiæ and tarsi dark brown, clothed with a golden-yellow pubescence that is especially distinct in the female. Wings gray, the stigma darker brown, lying beyond *r;* veins dark brown, the base of the wing slightly brighter. Venation: Cell *1st* M_2 open by the atrophy of the outer deflection of M_3; basal

deflection of Cu_1 just before the fork of *M; 2nd anal* vein sinuous, at its tip bent rather strongly toward the first anal.

Abdomen dark brownish black. Male hypopygium with the pleurites rather stout, covered with sparse prominent tubercles that bear coarse yellow setæ, which are longest at the tips of the pleurites; pleural appendages two, the outer appendage fleshy, the outer face with an abundant short brownish, appressed pubescence, arranged in transverse rows; inner appendage narrowed and chitinized at the tip, the inner face with about nine or ten stout setæ. Penis-guard terminating in two subparallel slender black spines; two pairs of gonapophyses, the inner pair simple and ending in an acute blackened point; outer gonapophyses bifid, the lateral arm much longer and more slender than the proximal arm. Eighth sternite with a short, flattened, subspatulate median lobe.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, April 2, 1919 (R. Takahashi).

Allotopotype, ♀, April 7, 1919.

Paratopotypes, 19 ♂ ♀, March 25–April 25, 1919; paratype, ♀, May 29, 1919; 6 ♂ ♀, October 2–21, 1919.

The autumnal specimens are much smaller than the vernal material, but show no other differences.

It is with great pleasure that this interesting fly is dedicated to its discoverer, Mr. Ryoichi Takahashi.

Erioptera Meigen.

Erioptera bifurcata sp. n.

General coloration gray, the mesonotum with three brown stripes; legs black with whitish scale-like hairs; wings yellowish, vein *Sc* yellow; cell *1st* M_2 open; anal veins divergent.

Male—Length, 5–5.5 mm.; wing, 6.1–7.1 mm.

Rostrum black, densely gray pruinose; palpi dark brown. Antennæ black, the segments oval, covered with a dense white pubescence, the verticils short, barely projecting beyond the pubescence. Head broad, light gray, the eyes widely separated above, the ventro-caudal angles almost contiguous beneath.

Pronotum light gray. Mesonotal praescutum gray with three brown stripes, the median stripe broad, slightly constricted by the conspicuous, elongate pseudosutural foveæ, indistinctly bisected by a pale median line; tuberculate pits small, very widely separated, lying slightly anterior to the level of the pseudosutural foveæ; scutum gray, the lobes indistinctly marked with brown; remainder of the mesonotum gray. Pleura clear light gray. Halteres light yellow, the extreme base dark. Legs with the coxæ and trochanters black, gray pruinose; remainder of the legs black, densely covered with flattened whitish, scale-like hairs. Wings with a faint yellow tinge, the base of the wing

more yellowish; stigma very narrow and indistinct, brown, confined to vein R_1; veins dark brown, *Sc* yellow. Venation: *Sc* long, ending opposite *r; r* on R_2 about its own length beyond the fork of R_{2+3}; cell *1st* M_2 open by the atrophy of *m;* basal deflection of Cu_1 beyond the fork of *M;* anal veins divergent.

Abdominal tergites gray, the sixth and seventh segments with a transverse median brown blotch; the basal segments on either side with blackish impressed rectangular areas; pleural appendages of the hypopygium yellowish with the tips blackened. Male hypopygium with the ninth tergite deeply notched medially; pleurites rather slender, at the apex with two pleural appendages; dorsal appendage long, slender, the tips blackened; ventral pleural appendage short, deeply bifid, the cephalic or proximal arm more slender, at its tip with a single long bristle; the caudal or lateral arm broader, its flattened apex densely set with roughened tubercles. Gonapophyses very long, almost straight, tapering to the acute tips.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, April 4, 1919 (R. Takahashi).

Paratopotypes, 4 ♂'s, April 4–9, 1919.

Limnophila Macquart.

Limnophila (Lasiomastix) **pilifer** sp. n.

Antennæ short in both sexes; wings yellowish at the base, the apical cells strongly pubescent.

Male—Length 6–7 mm.; wing, 8.6–8.7 mm.

Female—Length, 8.5–9.5 mm.; wing, 8.8 mm.

Rostrum and palpi dark brownish black. Antennæ short in both sexes; first scapal segment reddish brown, sparsely gray pruinose, second segment reddish; basal segments of the flagellum brown, paler basally, apical flagellar segments more elongate, dark brown; flagellar segments clothed with a pale pubescence. Head gray.

Pronotum large, dark colored, light gray pruinose. Mesonotum shiny jet black with an easily removed, but dense pollen, brownish yellow on the median area of the praescutum, clearer gray on the remainder of the thorax, including the pleura. Halteres light yellow. Legs with the fore coxæ black, grayish pruinose; middle coxæ dull brownish yellow, dark at the extreme base; hind coxæ largely brownish yellow; trochanters dull yellow; femora yellow, the tips broadly dark brown; tibiæ yellowish brown, the tips darkened; tarsi dark brownish black, the base of the metatarsi brown. Wings grayish, strongly yellow at the base, this color including most of the costal and subcostal cells; stigma oval, grayish brown, almost evenly split by *r;* narrow gray seams along the cord, outer end of cell *1st* M_2, origin of *Rs*, and the forks of R_{2+3} and M_{1+2}; veins brown, those in the costal and basal regions yellowish; apical cells of the wings strongly pubescent, this extending from cell *2nd* R_1 to cell Cu_1. Venation: Sc_2 slightly removed from the

tip of Sc_1; *Rs* long, in alignment with R_{2+3}, this latter shorter than the basal deflection of Cu_1; *r* removed from the tip of R_1; inner ends of cells R_3, R_5, and *1st* M_2 in oblique alignment; petiole of cell M_1 about equal to or shorter than this cell; basal deflection of Cu_1 slightly before mid-length of cell *1st* M_2. Some of the specimens in this series show abnormal types of venation.

Abdomen dark brownish black, the hypopygium a little reddish. Male hypopygium with the outer appendage almost straight, split into two short points at the apex; the inner appendage deeply bifid, the outer arm flattened, subspatulate, the blade setigerous, the inner arm much smaller and narrowed to the blunt apex; gonapophyses slender, acicular, much twisted. Valves of the ovipositor rusty horn color, very long and slender, the tergal valves almost straight, slightly upcurved at the tips.

Habitat: Japan.
Holotype, ♂, Meguro, Tokio, April 8, 1919 (R. Takahashi).
Allotopotype, ♀, April 19, 1919.
Paratopotypes, 18 ♂ ♀, April 7–25, 1919.

Limnophila (Ephelia) **subaprilina** sp. n.

Mesonotal praescutum yellowish gray, the lateral brown stripes connected with the intermediate pair by a subtransverse brown line; wings with a heavy brown pattern; abdominal segments bicolorous.

Male—Length, 5.6 mm.; wing, 7.3–7.4 mm.

Female—Length, 8.7 mm.; wing, 8.4 mm.

Rostrum and palpi dark brown. Antennæ with the scapal segments dark brown, the basal flagellar segments pale brown, the apical segments darker. Head brownish gray, more yellowish along the inner margin of the eyes and on the front.

Mesonotal praescutum yellowish gray with broken dark brown stripes; the intermediate stripes are separated from one another by a distance that is nearly equal to the width of one, indistinct in front, not reaching the suture behind; lateral stripes short, their cephalic ends with a transverse bar to form a T-shaped mark that connects more or less completely with the intermediate stripes and with the lateral margin of the praescutum; scutum yellowish gray; scutellum and postnotum clearer gray. Pleura yellowish gray with conspicuous dark brown blotches. Halteres yellow, the knobs dark brown. Legs with the coxæ dark brown; trochanters brown, with a black spot on the posterior face; femora dull yellow, the tips broadly dark brown; tibiæ brownish yellow, the tips narrowly and indistinctly darkened; tarsi dark brown, the first and second segment yellowish brown with only the tips darkened. Wings grayish subhyaline, the costal and subcostal cells more yellowish; a heavy dark brown pattern along the costal margin and large grayish brown blotches on the cross veins, deflections of veins, and along the margin at the ends of the longitudinal veins; there are seven costal blotches, the basal one broken, subocellate; the

third at the origin of *Rs* extending from costa almost to *M;* the fifth, largest, at the stigma; the last two at the ends of R_1 and R_2 respectively; a narrow cloud in the anal angle of the wing; the seam along the supernumerary cross vein sends a very black line along vein *Cu* to form an inverted T; veins *C* and *Sc* yellow, the other veins brown. Venation: *Rs* strongly arcuated at origin; R_{2+3} and M_{1+2} nearly equal in length.

Abdominal segments bicolorous, the basal half of each segment dull reddish, the apical half blackish. Male hypopygium with the outer pleural appendage stout, on the outer face before the tip with one conspicuous spine in addition to the apical, slightly curved, tooth.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, April 20, 1919 (R. Takahashi).

Allotopotype, ♀, April 19, 1919.

Paratopotype, ♂, April 19, 1919; paratype, ♂, Tokio, May, 1919.

Limnophila (Prionolabis) **rufipennis** sp. n.

General coloration blackish, femora a little paler basally; wings brownish yellow with sparse brown seams along the cord; cell *1st* M_2 subquadrate, basal deflection of Cu_1 beyond the middle of its length.

Male—Length about 14 mm.; wing, 16.4 mm., its greatest width, 5.5 mm.

Description from an alcoholic specimen.

Rostrum, palpi and antennæ black. Head black, very possibly grayish pruinose in dried specimens.

Thorax black throughout in alcoholic material. Halteres long, light yellow, the knobs a little darker. Legs with the coxæ black; trochanters dark brown; femora dark brown, only a little paler basally, especially on the hind femora; tibiæ and tarsi dark brownish black. Wings very broad and ample, deeply suffused with pale brownish yellow, clearer yellow in the costal and subcostal cells; stigma oval, dusky brown; very narrow dusky brown seams along the cord, at the outer end of cell *1st* M_2, at the origin of *Rs* and at the fork of M_{1+2}. Venation generally similar to *L.* (*P.*) *rufibasis* O. S. (Northeastern North America), but cell *1st* M_2 much shorter, subquadrate; R_{2+3} a little longer than *r-m;* basal deflection of Cu_1 beyond mid-length of cell *1st* M_2; petiole of cell M_1 a little shorter than this cell.

Abdomen dark brownish black. Male hypopygium with the ventral pleural appendage irregularly pectinated, one tooth being considerably larger than the others; dorsal pleural appendage with the apex simple, blackened.

Habitat: Japan.

Holotype, ♂, Chichibu, Province Saitama, October, 1918, (R. Takahashi).

Polyangæus Doane.

Polyangæus japonicus sp. n.

Thorax yellow, the praescutum with an indistinct darker median stripe; wings with a heavy brown banded pattern; crossvein *r* lacking, *m* present; supernumerary crossveins in cells R_3, R_5, M_1 and M; tibiæ and tarsi largely white.

Male—Length, 6.6 mm.; wing, 8 mm.

Head small, closely applied to the thorax. Rostrum and palpi dark brown. Antennæ short, the flagellar segments crowded, the scape dark brown, the flagellum light brownish yellow, the last segment infuscated. Head dark brownish gray.

Mesonotum light yellow, the praescutum with a broad pale brown median stripe that is broadest and most distinct in front, becoming obliterated behind; postnotum brownish. Pleura yellow. Halteres very long and slender, dark brown, the base of the stem yellow. Legs with the coxæ and trochanters dull yellow; femora dull yellow, the tips broadly dark brown; tibiæ china-white, the tips broadly dark brown; tarsi white, the apical segments more infuscated. Wings subhyaline with a heavy banded pattern of dull yellowish, margined with brownish gray; the costal cell is entirely dark; interrupted crossbands occur at the origin of the sector, along the cord and very diffusely between the cord and the wing-tip; dark spots at the ends of all the longitudinal veins, large and blotch-like at the ends of the anal veins; a row of small dots in cell *Cu*, behind the abortive anal vein in that cell; two spots in the base of cell *1st A*; the apical pattern consists of yellowish seams to the crossveins, these markings broadly margined with brownish gray to produce a somewhat ocellate appearance. Venation: *Rs* square and spurred at its origin; *r* lacking but a strong spur at the angle of R_{2+3} at the point where *r* is located in the genotype, *P. maculatus;* R_{2+3+4} longer than *r–m;* cell *1st* M_2 closed, *m* being located between M_2 and M_3; supernumerary crossveins in cells R_3 near the tip, R_5 at about two-thirds its length, at about midlength of M_1 and in cell *M* about in alignment with the angulated base of the sector.

Abdomen brown, the segments margined posteriorly with darker brown.

Habitat: Japan.

Holotype, ♂, Saitama, May 31, 1919 (R. Takahashi).

Polyangaeus japonicus agrees with the genotype, *P. maculatus* Doane (Western United States) in most features of its organization. It differs in the lack of the radial crossvein, the closed cell *1st* M_2 and the presence of an additional supernumerary crossvein in cell M_1.

Rhaphidolabis Osten Sacken.

Rhaphidolabis flavibasis sp. n.

Antennæ with fourteen segments, the last segment enlarged; mesonotal praescutum light gray, with three dark brown stripes; base of the wings strongly yellowish; male hypopygium with the outer angle not produced into a lobe, the appendages borne at the narrow apex.

Male—Length, 7 mm.; wing, 8.7–8.9 mm.

Female—Length, 7.5–8 mm.; wing, 9.4–9.8 mm.

Rostrum and palpi dark brown. Antennæ dark brownish black, the first scapal segment gray pruinose, the second scapal segment a little brighter apically; there are twelve flagellar segments which gradually decrease in size to the end of the terminal, one much larger than the penultimate and seemingly produced by the union of two small segments. Head light brownish gray, clearest along the inner margin of the eye; an indistinct dark median line; vertical tubercle low.

The mesonotal praescutum light gray with three dark brown stripes, the intermediate stripe entire; remainder of the mesonotum plumbeous, gray pruinose. Pleura light gray. Halteres dark brown, the basal third of the stem bright yellow. Legs with the coxæ gray; trochanters brown; femora dark brown, brighter on the basal third; tibiæ and tarsi dark brownish black. Wings grayish subhyaline, the costal and subcostal cells a little more yellowish; base of the wings bright yellow, including the veins; stigma distinct, brown; veins dark brown. Venation: *Rs* short, slightly arcuated to feebly angulate near midlength; R_2 ublique, its fusion with R_1 at the wing tip slight; R_{2+3+4} rather short, osually a little longer than *r-m;* cell M_1 present; cell *1st* M_2 open.

Abdomen dark brown, sparsely gray pruinose. Male hypopygium with the pleurites short and stout, at the apex with the two small pleural appendages, an outer subcircular fleshy lobe whose inner face is densely set with short black spinous setæ; inner pleural appendage more chitinized, slightly curved, along the inner margin with about a dozen spinous setæ that are stouter and more crowded near the tip; lateral gonapophyses slender, bent at a right angle near midlength. Ovipositor rusty in color.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, March 27, 1919 (R. Takahashi).

Allotopotype, ♀, April 4, 1919.

Paratopotypes, 8 ♂ ♀, March 20–April 9, 1919.

One teneral female that may represent still another undescribed species has cell R_3 sessile, the petiole being entirely lacking. The praescutal stripes are less distinct than in the specimens above described.

Dicranota Zetterstedt.

Dicranota nipponica sp. n.

Antennæ with twelve segments, the terminal segment small; mesonotal praescutum grayish buff, with three dark brown stripes, the median one of which is split by a capillary line of the ground color; male hypopygium at the outer angle produced caudad into a lobe.

Male—Length, 7.5 mm.; wing, 8.7 mm.

Rostrum and palpi brown. Antennæ dark brownish black, the flagellar segments with a conspicuous erect white pubescence in addition to the verticils; but ten flagellar segments are evident, the last much smaller than the penultimate; first flagellar segment long clavate, much longer than those following. Head brownish gray, very narrowly clearer gray along the inner margins of the eyes.

Thorax light grayish buff, the praescutum with three dark brown stripes of which the intermediate one is distinctly split by a capillary vitta of the ground color; scutal lobes gray marked with pale brown; scutellum, postnotum and pleura light gray. Halteres pale brown, brighter at the base. Legs with the coxæ light gray, more yellowish apically; trochanters dull yellow, the outer margins blackened; femora brownish yellow, brighter at the base, the tips dark brown; tibiæ dark brown, the tips black; tarsi dark brownish black. Wings with a pale gray tinge; stigma elongate, brown, extending from *r* to the tip of R_{1+2}; veins dark brownish black, the veins at the wing base a little paler. Venation: *Rs* very short, strongly angulated to almost square at its origin, slightly spurred; R_{2+3+4} short, about equal to *r-m;* apical fusion of R_2 with R_1 slight; cell *1st* M_2 open, cell M_1 present.

Abdomen dark brownish gray, the tergites very narrowly margined caudally with paler gray; sternites similarly margined with yellowish gray and with an indistinct broken median yellowish stripe. Male hypopygium with the outer angle of the pleurites extended caudad into a blunt hairy lobe; two pleural appendages, the inner one of which is curved, flattened and expanded distally, not conspicuously armed with setæ and spines.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, March 30, 1919 (R. Takahashi).

Cylindrotoma Meigen.

Cylindrotoma japonica sp. n.

Antennæ rather short, dark brownish black; front and a broad margin around the eyes yellow; praescutal stripes entirely confluent, the interspaces with a deep grooved impression.

Male—Length about 13–14 mm.; wing, 10.8–11.5 mm.

Female—Length, 13.5 mm.; wing, 13 mm.

Rostrum and palpi dark brown. Antennæ rather short for this genus of flies, dark brownish black, the flagellar segments with the posterior face straight, the anterior or inner face gently convex. Front and a broad margin around the eyes yellow, remainder of the head shiny black, microscopically punctured.

Pronotal scutum dark, the scutellum yellow, darker medially. Mesonotal praescutum with the disk black, subopaque, with deep, impressed longitudinal grooves in the usual interspaces; scutal lobes and the posterior half of the postnotum black, remainder of the mesonotum yellow. Pleura pale whitish yellow, the sternopleura and mesopleura, as well as an oval spot cephalad of the base of the halteres shiny black. Halteres pale yellow, the knobs scarcely darker. Legs with the coxæ light brown, the outer face marked with darker brown; trochanters dull yellow; femora yellow, the tips broadly black; tibiæ brownish yellow, tipped with black; tarsi black, the base of the metatarsi a little paler. Wings broad, grayish yellow, the basal and costal areas brighter; stigma dark brown, oval; veins dark brown. Venation: cell *1st* M_2 not greatly elongated; cell M_1 short-petiolate.

Abdominal tergites reddish brown, the segments margined laterally and caudally with black; in some specimens these markings completely cover the dorsum; sternites reddish, indistinctly margined laterally and caudally with dark brown; male hypopygium greatly enlarged, black; ovipositor black.

Habitat: Japan.
Holotype, ♂, Saitama, May 29, 1919 (R. Takahashi).
Allotopotype, ♀, May 31, 1919.
Paratopotypes, 2 ♂s.

Liogma Osten Sacken.

Liogma serraticornis sp. n.

General coloration deep shiny black; flagellar segments in the male deeply serrated; wings with the stigma yellow or brownish yellow.

Male—Length about 15 mm.; wing, 12–12.1 mm.

Female—Length about 14 mm.; wing, 12 mm.

Rostrum dark brown; palpi yellowish brown. Antennæ with the scape brownish yellow, the flagellum dark brownish black, the flagellar serrations in the male sex very long, considerably more so than in *L. kuwanai;* there are seventeen segments, the last two of which are slender and not serrate. Head shiny black.

Thoracic dorsum shiny black, the postnotum sculptured. Pleura shiny black, the dorso-pleural membranes pale. Halteres yellow. Legs with the coxæ largely black on their outer faces; trochanters dull yellow; femora pale yellow, the tips broadly black; tibiæ yellowish brown, the tips blackened; tarsi black. Wings with a strong yellowish gray tinge, the costal region, the stigma and the space between *Cu* and the abortive anal vein behind it yellowish; veins dark brown, excepting

Sc and *R*, which are yellowish. Venation: *r-m* sometimes present, but short, at other times obliterated by the punctiform contact or short fusion of R_{4+5} on M_{1+2}; basal deflection of Cu_1 before or slightly beyond the fork of *M*.

Abdomen shiny black throughout.

In the female sex, the antennæ are much shorter and less distinctly serrated; only the second scapal segment is pale; the stigma and costal region of the wing brownish yellow; the valves of the ovipositor short and flattened, black, their tips rusty brown.

Habitat: Japan.

Holotype, ♂, Saitama, May 30, 1919 (R. Takahashi).

Allotopotype, ♀, May 29, 1919.

Paratopotypes, 2 ♂'s, 2 ♀'s, May 29, 1919.

Liogma kuwanai is a gray fly with the stigma dark brown and the femora brown with only the bases yellow.

Phalacrocera Schiner.

Phalacrocera mikado sp. n.

Antennæ simple; mesonotum shiny black, the lateral margins of the praescutum, the scutellum and the anterior half of the postnotum pale; abdomen shiny black.

Male—Length about 11 mm.; wing, 12.2 mm.

Female—Length about 12 mm.; wing, 11.5–11.8 mm.

Rostrum and palpi dark brown. Antennæ with sixteen segments, simple in both sexes; in the male elongate-cylindrical, clothed with an abundant white pubescence; antennæ dark brown, the bases of the first two flagellar segments more yellowish. Head with the vertex between the eyes pale brown, the remainder shiny brownish black. Head strongly narrowed behind.

Mesonotal praescutum shiny black, the lateral margins and the humeral regions pale; scutal lobes black; remainder of the dorsum pale except the posterior portion of the postnotum, which is darkened. Pleura pale, the mesopleura and sternopleura shiny black. Halteres pale brown, the base of the stem paler. Legs with the coxæ pale, the outer faces more or less darkened, especially on the mesocoxæ; trochanters pale; femora pale, the tips dark brown; tibiæ pale brownish white, the tips dark; tarsi dark brown. Wings pale grayish, the stigma oval, pale yellowish brown; veins brown. Venation: *m* and *r-m* present, long; in the allotype the tip of vein R_2 is indistinctly persistent in both wings, but in the other specimens there is no trace of this vein.

Abdomen shiny black; hypopygium small.

Habitat: Japan.

Holotype, ♂, Tokio, April, 1919, (R. Takahashi).

Allotopotype, ♀.

Paratype, ♀, Saitama, May 29, 1919, (R. Takahashi).

Nesopeza Alexander

Nesopeza tarsalis sp. n.

Mesonotal praescutum with the stripes shiny brown, confluent; legs black, the tips of the tarsi white; wings with the stigma dark brown, with a pale area before and beyond it.

Male—Length about 10 mm.; wing, 12 mm.

Female—Length about 13 mm.; wing, 12.3 mm.

Frontal prolongation of the head and the palpi dark brown. Antennæ of the male moderately elongated, if bent backward extending about to the base of the abdomen, the scape yellow, the flagellum dark brown. Head yellowish, passing into dark brown on the posterior portions of the vertex.

Mesonotal praescutum shiny brown, the stripes confluent, the humeral angles yellowish; scutal lobes dark; remainder of the mesonotum paler. Pleura yellowish with a shiny black streak or band extending from the sternum across the mesopleura to the praescutum; a black spot between the middle and hind legs. Halteres dark brown, the base of the stem paler. Legs with the coxæ and trochanters yellow; femora dark brown, paler at the base; tibiæ and tarsi dark brownish black, the tips of the latter pure white, these about equal in width on all the legs or a trifle broader on the hind legs where about the apical half is pale. Wings gray, the stigma dark brown; a whitish subhyaline area before and beyond the stigma; a narrow seam on the basal deflection of R_{4+5} and the tip of the wing faintly infuscated. Venation: *Rs* not so elongate as in *N. geniculata* and the medial forks deeper.

Abdomen shiny dark brown, the basal sternites and the sides of the second and third tergites more yellowish; hypopygium brownish black. In the female the abdominal tergites are uniformly dark.

In the living specimens the body is probably with decided greenish tints as traces of these persist in the pinned individuals.

Habitat: Japan.

Holotype, ♂, Saitama, May 29, 1919 (R. Takahashi).

Allotopotype, ♀.

Paratopotype, ♀.

Tipula Linnæus.

Tipula joana sp. n.

Antennæ black, the scape orange-yellow; praescutum gray with three darker gray stripes, the median stripe split by a capillary black line; wings strongly petiolate, a seam along the cord and the apex brownish black; *2nd Anal* cell very narrow.

Male—Length, 18–20 mm.; wing, 17–18 mm. Fore leg, femur, 11 mm.; tibia, 13.6 mm.; hind leg, 13 mm.; tibia, 15.8 mm.

Frontal prolongation of the head reddish brown, the dorsal surface light gray pruinose; nasus distinct. Palpi pale brown, the last segment,

with the exception of the base, light yellow. Antennal scape orange-yellow, the flagellum black, the segments of the latter nearly cylindrical, with a dense, microscopic white pubescence. Head light gray, the sides of the vertex more brownish, set with abundant setæ.

Mesonotal praescutum light gray, with three darker gray stripes, the median stripe broadest, strongly narrowed behind, split by a capillary velvety-black line; scutum light gray, each lobe with two darker gray blotches; scutellum and postnotum darker gray. Pleura dark colored, with a dense blue-gray pollen, the dorso-pleural membrane conspicuously dull yellow. Halteres brown, the extreme base brownish yellow. Legs with the coxæ blue-gray; trochanters yellow; femora brownish-yellow, brightest at the base, the tips brownish black; tibiæ brownish black, darkest apically, the posterior tibiæ with a broad, indistinct, whitish, sub-basal band; tarsi black. Wings with a faint yellowish tinge, brightest at the wing-base; costal cell more saturated; subcostal cell dark; stigma dark brownish black; a broad dark brownish black seam along the cord; wing-apex blackish, this occupying the end of cell R_2, nearly the apical half of cells R_3 and R_5 and part of M_1. Venation: *Rs* short; R_2 persistent; *2nd Anal* vein running very close to the anal margin so the *2nd Anal* cell is very narrow. The wing is strongly petiolate.

Abdomen with the basal tergites yellowish, especially laterally, the fifth to ninth tergites black; sternites paler; abdominal segments margined laterally and ringed caudally with paler. Male hypopygium not conspicuous; ninth tergite rather small, the caudal margin almost straight across or but feebly notched. Outer pleural appendage rather small, flattened, greenish white in color, broadest at the base, tapering gradually to the apex. Inner pleural appendage pale greenish, terminating in two subequal blackened spines that are slightly divergent, claw-like; a broadly spatulate blade projects toward the ninth tergite. Ninth sternite with a small but deep V-shaped median notch. Eighth sternite projecting caudally, the margin unarmed.

Habitat: Japan.

Holotype, ♂, Meguro, Tokio, April 23, 1919 (R. Takahashi).

Paratopotype, ♂.

This exquisite species is dedicated to the memory of my mother, Mrs. Jane Parker Alexander. It shows numerous points of resemblance to *T. pedata* Wied. and allied forms and if the group *Tipulodina* Enderlein is to be recognized as a valid genus this species will probably have to be placed therein, although the hypopygium is strikingly different from that of the genotype of *Tipulodina* (*pedata*). For a discussion of the status of the group *Tipulodina*, consult a paper by the writer, Proceedings of the United States National Museum, vol. 49, p. 184; 1915.

WING STRUCTURE OF LEPIDOPTERA AND THE PHYLOGENETIC AND TAXONOMIC VALUE OF CERTAIN PERSISTENT TRICHOPTEROUS CHARACTERS.

By Annette F. Braun, Cincinnati, O.

I. Introduction.
II. Wing Structure.
(a) Venation.
(b) Mode of insuring synchronous action of fore and hind wings.
(c) Distribution of fixed hairs.
III. Summary and Conclusions.
IV. References.

I. Introduction.

It is agreed that the insects constituting the two orders Trichoptera and Lepidoptera respectively are closely related genetically. All insects included in these orders have the same general and characteristic type of venation, which in the more primitive forms closely approaches the hypothetical primitive type as figured by Comstock. It is the problem of determining where the line of division shall be drawn between Lepidoptera and Trichoptera which presents difficulties. According to the usually accepted classification, the Micropterygidæ are regarded as the most primitive group of Lepidoptera, from which all the other Lepidoptera have been derived. This group more closely resembles in venation and mode of uniting the fore and hind wing in flight the more generalized of the Trichoptera than it does any other group of insects, evidently approaching the stem form from which both groups have been derived. On the basis of certain common and characteristic features in venation, and the identical structure of the fibula in both, Comstock ('18) removes the Micropterygidæ from the Lepidoptera, confirming his conclusion by the results of Dr. T. A. Chapman's studies of pupæ, and makes them one suborder of the Trichoptera, the Micropterygina, the members of Trichoptera as usually recognized constituting the other suborder, the Phryganeina.

In addition to the Micropterygidæ, there is another group of moths, the Nepticulidæ, the more generalized members of which possess a fibula identical in structure with that of the

Micropterygidæ and the generalized Trichoptera,* and a pupa resembling that of the Microptergyidæ. The venation of the Nepticulidæ (Braun, '17) shows highly specialized features. It resembles most closely the venation of some of the Hydroptilidæ, but shows extreme anastomosis of main veins and absence of cross-veins. It differs from that of Hydroptilidæ chiefly in the few points in which the Nepticulidæ approach the usual type of venation in the frenate Microlepidoptera with reduced venation. The existence of this group, which shows undoubted trichopterous affinities, further complicates the question of the true relationship existing between the Trichoptera, the Micropterygidæ, the Nepticulidæ, the Hepialidæ, and the frenate Lepidoptera.

The discovery of another family, the Prototheoridæ (Meyrick, Annals South African Museum, XVII, 17, 1917), with characters intermediate between the Micropterygidæ and the Hepialidæ, would seem to make it impossible to place the Micropterygidæ and Hepialidæ in different orders.

In two related groups, any adaptation for a particular function may have been handed down from the common ancestor of the two, or it may be a similar modification of an homologous structure arising independently in each group, because of the same inherent tendencies in each, or the adaptations serving the same purpose may be developments of entirely different structures in the two groups. The two former conditions indicate community of descent and closeness of relationship; the third the phylogenetic divergence of the two groups. The same principles may be applied in the analysis of the entire structure of the groups whose true relationship is to be determined. If it can be shown, that the more primitive members of one group having many characteristics in common with the primitive members of another group and thus appearing more closely related to them than to any other group, show the beginning of divergence in structure from that other group, and these modifications can be consistently traced in the same direction through the more specialized members of the first group, in my opinion the point where the two groups begin to diverge, that is, the point where the distinctive characteristics of a group originate, is the logical place to make a taxonomic

* The term Trichoptera is used in this paper in its commonly accepted sense, not including the Micropterygidae.

division, even though an apparently wider gap may exist somewhere between two divisions of a group, due to incomplete preservation of connecting forms or insufficient knowledge on our part.

In the present paper, the relative value of those factors indicating community of descent and relationship of the insects constituting the Trichoptera and Lepidoptera and those indicating divergence is considered in its bearing on the question of classification.

With regard to the taxonomic problem involved, the question is essentially this: Are certain characteristics possessed by the Micropterygidæ in common with the Trichoptera of such taxonomic importance as to necessitate the conclusion that the Micropterygidæ are trichopterous insects or are these characteristics merely retained as a common inheritance, later to undergo far-reaching modifications which can be traced back to the Micropterygidæ.

Certain characters which are possessed in common by the Micropterygidæ and Trichoptera and which seem sharply to separate the Micropterygidæ from frenate Lepidoptera, will be shown to undergo far-reaching modification and in this modified form to persist in many of the comparatively primitive groups of the frenate Lepidoptera. The fact that the course of such modification can be traced makes it evident that the gap between the Micropterygidæ and the remaining Lepidoptera is not as wide as is sometimes supposed. This fact, and the fact that certain acknowledged lepidopterous characters originate in the Micropterygidæ, necessitate the conclusion that the Micropterygidæ are lepidopterous insects.

II. Wing Structure.

The structure of the wings presents the most obvious and available characters for the study of the phylogeny and taxonomy of the Lepidoptera and Trichoptera. The following discussion of the structure of wings of Lepidoptera deals with the modification and disappearance of trichopterous characters and with the origin of some distinctively lepidopterous characters. The data are presented under (a) venation, (b) mode of insuring synchronous action of fore and hind wings, (c) distribution of fixed hairs.

(*a*) *Venation.*

Certain striking characteristics of venation are held in common by the more generalized Trichoptera, such as *Rhyacophila* and by the more generalized of the Micropterygidæ. These characteristics have been enumerated by Comstock (The Wings of Insects, 1918, p. 317). In fact, the resemblance is so close that the only essential difference to be noted is that in Micropterygidæ media of both wings has been reduced to a three-branched condition, apparently by the coalescence of M_3 and M_4, while in *Rhyacophila* M_3 and M_4 are separate in the fore wing, although united in the hind wing. This identity of characteristics is shared by no insect not belonging to Micropterygidæ or Trichoptera. That it is possible to trace the modification of these trichopterous characters and their transformation into what are commonly recognized as the usual lepidopterous characters, such as are found in the frenate Lepidoptera, will be shown from evidence derived from the Micropterygidæ themselves, the Nepticulidæ, the more primitive frenate Lepidoptera, and the Hepialidæ.

The forms for study of venation in the more primitive Lepidoptera have been chosen because they show, besides the preservation of media, certain characters—such as the costal spines on the hind wing, absence of frenulum in the female, fixed hairs on the wings and folded maxillary palpi—all of which indicate a generalized condition.

In the Micropterygidæ veins *Cu* and *1st A* of both fore and hind wing coalesce at the base of the wing; from their point of separation *Cu* extends obliquely across the wing toward media, then bends and extends longitudinally to the margin. In the hind wing, the point of separation of *Cu* and *1st A* is nearer the base than in the fore wing. A short cross-vein, the posterior arculus, connects media with the longitudinal part of *Cu*, forming with the base of media, a serial vein in the fore wing. The presence of this condition in *Mnemonica* and in *Rhyacophila* is pointed out by Comstock in his book "The Wings of Insects," where wings of both are figured together with figures of the tracheation in the base of the wings of *Mnemonica*, which confirm the homologies of the veins as determined from a study of adults. In so far as published figures of other genera of the Micropterygidæ show the details

of venation at the base of the wings, they indicate that these conditions are common to all members of the family, although not without modification which may tend to obscure these characters. That such modification does take place in the Micropterygidæ, is shown by an examination of the wings of *Epimartyria* (Fig. 1), which genus, since it precedes the appearance of the tongue, must be regarded as a more primitive genus than *Mnemonica*. In the fore wing, the configuration of these veins is essentially that of *Mnemonica*. In the hind wing, *Cu* extends straight to the margin from its point of separation from the *1st A*, that is, the "oblique" part of *Cu* has become so extremely oblique as to be in a line with the longitudinal part of *Cu*. As is to be shown presently, this differs in no way from the course of *Cu* of the hind wing in certain undisputed Lepidoptera. In *Prodoxus*, most of the tracheae are preserved in the extreme base of the wings. Figure 2 shows the more general features of the venation, with wavy lines representing tracheæ; Figure 3 shows in detail the course of the tracheæ at the extreme base of the hind wing. In the fore wing the coalesced bases of *Cu* and *1st A* contain a single trachea, which soon divides, one branch following the *1st A*, the other branch immediately dividing again, both branches traversing *Cu*, but soon shriveling up. That portion of *Cu* between its separation from *1st A* and the posterior arculus (which is here transverse and contains no trachea) is evidently homologous with the oblique free portion of *Cu* in Micropterygidæ and Trichoptera. The tracheæ in the base of the hind wing (Fig. 3) show that the relations of *Cu* to the *1st A* are apparently the same as in the fore wing, but the separation takes place extremely close to the base, and the course of the veins is obscured by the tuberosities at the base of the wing. It will be observed that the vein containing a branched trachea, evidently the cubital trachea, is met very obliquely near the base of the wing by a vestige of what appears to be the posterior arculus. The evidence afforded by a study of pupal wings of *Prodoxus* (Fig. 6) supports the conclusions derived from a study of adult wings. The coalescence of *Cu* and *1st A*, the Z-shaped course of *Cu*, and the formation of the serial vein are sometimes shown with greater distinctness in the fore wing of *Adela bella* (Fig. 5), where these features of the venation are almost exactly as in *Mnemonica;* a similar condition is present

in the hind wing. The course of these veins is also the same in *Cyanauges cyanella*, as reference to Figure 4 will show; in this case the separation of *Cu* and *1st A* occurs almost at the base of the wing.

The obvious conclusion to be drawn from this series of examples is that in the course of evolution, the point of separation of *Cu* and *1st A* moves toward the base of the wing, and concomitant with this change, the oblique basal part of *Cu* becomes more and more oblique until by the time the point of separation has reached the base of the wing, the formerly oblique free basal part of *Cu* is in a line with the longitudinal part of *Cu*. There will thus be no evidence in the venation of this part of the wing in the more specialized Lepidoptera to indicate that it is derived from a venation like that of *Mnemonica*. What appears to be the posterior arculus is usually obsolescent (as indicated in the Figures by dotted lines), but vestiges of it sometimes traversed by a persistent trachea are present in many Lepidoptera belonging to widely separated groups, e. g., in Tineidæ (e. g., *Tineola*), Plutellidæ (e. g., *Pliniaca*), Eucleidæ (e. g., *Sisyrosea textula*), Tortricidæ, and possibly in other groups. The question whether this is really the posterior arculus or the base of M_4 is not discussed here. In the light of what has been shown to have taken place in more primitive forms, the configuration of veins in the base of the fore wing of the Noctuid, *Renia flavipunctalis* (Fig. 7), suggests the same course of evolution. The coalescence of the base of the first anal trachea with the cubital trachea, shown in the pupæ of some butterflies, and in some of the specialized moths (e. g., *Samia cecropia*), I am inclined to regard as a secondary connection, following the separation of *Cu* and *1st A* at the base.

The venation of the fore wing of the more generalized members of the Nepticulidæ is characterized by the basal coalescence of media and cubitus, a character unique in Lepidoptera, but whose origin can be explained by assuming that processes similar to what is known to occur in some Trichoptera have taken place. The cubital and medial tracheæ lie within the same vein cavity near the base (Fig. 8), the two separating at the point where media bends forward to join radius. This characteristic of the venation of the Nepticulidæ can be derived from an ancestral form in which cubitus followed

the course common to *Mnemonica* and *Rhyacophila*, if we assume an anastomosis of *M* and *Cu*, obliterating the posterior arculus (such as Comstock shows has taken place in a species of *Rhyacophila*) to have proceeded to the base of the wing. This view is strengthened by the course of the persistent cubital trachea in the fore wing of a specimen of *Nepticula platanella* (a comparatively generalized species of its genus) which follows the first anal vein at the base, bending obliquely toward media which it reaches at the point where media bends upward toward radius, then extending longitudinally along the usual course of cubitus. The venation of the hind wing shows an advance over that of the fore wing, even in the most generalized Nepticulidæ, in that media and radius coalesce for half their length; this condition, which is brought about by the crossing over of media to radius at the base has been attained in part of the genus *Nepticula* in the fore wing.

In the Hepialidæ the course of cubitus of the fore wing is the same as it is in the Micropterygidæ. In the hind wing *Cu* is free from *1st A* at its base; there is no evidence from pupal wings or adult forms to indicate how this condition may have been derived from one in which *Cu* follows the same course as in the fore wing.

The coalescence of the tips of two branches of the third anal vein with the tip of the second anal vein of the fore wing is a character common to both the more generalized Trichoptera and Micropterygidæ. The second branch of the third anal vein tends to disappear very early in phylogeny, although the third anal trachea is often forked in the pupa. Even in the most primitive Micropterygidæ, as *Sabatinca*, this coalescence of veins is shown in one species and not in the other. The second branch of the third anal vein is but faintly shown in *Epimartyria* (Fig. 1). In *Scoliaula* of the Nepticulidæ, there is a faint indication of a second branch of the third anal vein, represented merely by a broad slight thickening of the wing membrane, but neither it nor the first branch continue far enough to unite with the second anal vein. In Hepialidæ, the second branch of the third anal vein shows no tendency to unite with the first branch, but runs close to the margin of the wing. Among the Frenatæ, the condition of the branches of the third anal vein in *Prionoxystus* is similar to that in Hepialidæ.

In *Prionoxystus robiniæ*, the second branch of the third anal closely parallels the axillary furrow; the third branch follows the free margin of the posterior lobe. As shown later, the inner margin of the fore wing in this species clasps the costa of the hind wing. In other Frenatæ, I have found no indication of the presence of the second branch of the third anal vein. It is suggested as a plausible explanation of the atrophy of this vein that its disappearance is correlated with the loss of the holding function by this part of the wing.

The cross-vein between the first and second anal veins of the fore wing, which is present in Micropterygidæ and Trichoptera, is preserved in many of the primitive Frenatæ as well as in the Hepialidæ. It is shown distinctly in *Adela bella* (Fig. 5), and in *Prodoxus;* in a pupal wing of *Pronuba* this vein is as strong as the second anal. It is shown faintly in *Cyanauges cyanella*.

In the hind wing, the course of the second anal vein, which anastomoses with the first anal vein for a distance, is regarded by Comstock as a distinctly ordinal character, common to Micropterygidæ and Trichoptera (cf. The Wings of Insects, p. 310). The tracheation in the base of the hind wing of *Prodoxus* (Fig. 3), shows the same course of the second anal. The trachea of the second anal vein bends forward to the first anal vein, but almost immediately bends obliquely backward and after meeting the cross-vein between the second and third anal, extends in a longitudinal direction to the wing margin. The cross-vein is a much more distinct and well developed tubular vein than is the base of the second anal vein itself. The pupal tracheation of *Prodoxus* (Fig. 6) shows quite clearly the anastomosis of the first and second anal veins. In this instance the longitudinal cross-vein between the second and third anal veins is preceded by a trachea, which is apparently the first branch of the third anal itself. A similar condition is indicated by the course of these veins in *Cyanauges* and in *Adela;* in neither is verification possible through persistence of tracheæ. In *Adela* the base of the *2nd A* followed proximad, becomes indistinct before reaching the *1st A;* the cross-vein is quite distinct.

In Hepialidæ neither venation nor tracheation in the pupal wings (MacGillivray, '12), where there are three free anal tracheæ, indicates any such anastomosis.

Adela bella (Fig. 5) shows a branching of the third anal vein of the hind wing, similar to that in Micropterygidæ and Trichoptera.

It has just been shown that certain essential features of venation common to Micropterygidæ and Trichoptera and seemingly found in no other insects can be identified in more or less modified form in most of the more primitive Lepidoptera. In most cases the steps in this process of modification can be traced. The evidence is perhaps least satisfactory in the Hepialidæ, which would indicate their divergence from the other lepidopterous groups, a view borne out by other points of structure. It is apparent that these characteristic features of venation which the Micropterygidæ hold in common with the Trichoptera do not distinguish them from the rest of the Lepidoptera as sharply as might be inferred by a comparison of the Micropterygidæ with more specialized Lepidoptera only. The manner of specialization in the Nepticulidæ, with respect to the course of cubitus, is of especial value in determining the true phylogenetic relationship of the Micropterygidæ to the rest of the Lepidoptera. The course of modification in the more generalized Nepticulidæ, paralleling that sometimes occurring in Trichoptera, which is a divergence from the usual lepidopterous type, together with the possession of the fibula, undoubtedly indicates a common ancestry with Trichoptera, while certain other typically lepidopterous characters, such as the single spined frenulum of the male, the short tongue and six-jointed maxillary palpi characteristic of many primitive Frenatæ, obsolescence of the first anal vein of the fore wing, the reduction of radius of the hind wing in the same manner as it has taken place in the Frenatæ, place the Nepticulidæ with certainty in the Lepidoptera. This peculiar combination of characters in the Nepticulidæ, taken in connection with the undoubted specialization in venation, places them as the end group of a line of development divergent from that of the other Lepidoptera. Since these two *divergent* lines of development are both lepidopterous, the common ancestor must also be lepidopterous. It has just been shown, that the course of modification in venation in both lines of development can be traced back to Micropterygidæ, which therefore, on the basis of evidence derived from a study of venation, must be regarded as the common ancestor and is hence lepidopterous. To

remove the Micropterygidæ from the Lepidoptera, would necessitate the assumption that the Lepidoptera have originated twice or have been derived from a hypothetical lepidopterous ancestor so close to Micropterygidæ that it can not be separated from Micropteryidæ.

(*b*) *Mode of Insuring Synchronous Action of Fore and Hind Wings.*

The methods of holding the fore and hind wings together in flight show characteristics which are of value in a study of the phylogeny and relationships of the Trichoptera and Lepidoptera.

In the more generalized Trichoptera and in the most primitive groups of Lepidoptera, the posterior lobe of the fore wing has been modified to serve as an organ for holding the wings together, termed fibula or jugum, depending on mode of functioning. The fibula in the more generalized Trichoptera, such as Rhyacophila, and in certain of the Micropterygidæ, as *Mnemonica* in the subfamily Eriocraniinæ, acts by pressing downward over the base of the hind wing and clasping the anterior tuberosity of the hind wing. Tillyard ('18, '19) has described for certain genera of the two remaining subfamilies of the Micropterygidæ, the Mnesarchaeinæ and the Micropteryginæ, a different mode of functioning of the fibula. In these genera it is described as being bent under the fore wing and serving as a retinaculum for the series of costal spines of the hind wing.* My observations on *Epimartyria* in the subfamily Micropteryginæ tend to support this view.

The fibula in the female of the last specialized genera of Nepticulidæ (which find their nearest allies in characteristics of venation among the Hydroptilidæ in the Trichoptera) is identical in structure with the fibula in the more primitive Trichoptera and in the Micropterygidæ. In the Trichoptera the process of modification of the fibula has finally resulted in such a reduction in size and change in shape that the posterior lobe of the fore wing no longer bears any resemblance to a fibula and can not function to aid in holding the fore and hind wing together. In some forms, while not retaining the characteristic shape shown in the Rhyacophilidæ, the longitudinal free margin still shows the downward curve, thus indicating

* That these spines do not constitute a true frenulum and are not homologous with it, is shown in the pages following.

that it can still act by clasping the anterior tuberosity of the hind wing. The course of modification of shape in the posterior lobe of the fore wing in Nepticulidæ from a fibula in females of the more generalized genera can be traced through various changes until it becomes merely a narrow lobe whose free margin is continuous with the inner margin of the wing. Thus we find that while in the females of earlier genera the fibula has preserved its original structure and is apparently functional, in the males of these genera the posterior lobe is rather prominent but lacks the characteristic shape of the fibula as found in the Trichoptera and Micropterygidæ. In *Nepticula* the posterior lobe has lost all resemblance to the fibula; it is extremely narrowed and the axillary furrow is so indistinct as scarcely to separate it from the rest of the wing. This process, whose steps can be observed in this lepidopterous family, would seem to indicate the possibility that a similar process might have taken place in families of the Frenatæ, or in other words, that the Frenatæ have been evolved from ancestral forms in which a well developed fibula was present. There is some evidence to support this view. In *Prodoxus* the posterior lobe of the fore wing is more than usually prominent and is separated from the rest of the wing by a very distinct axillary furrow; it shows a strong tendency to fold under, thus seemingly retaining some of the function of the fibula, although it has lost its characteristic shape. In some Tineidæ, the posterior lobe of the fore wing bears some resemblance to a fibula, but it is not of a structure to be functional. In others of the Frenatæ where it can be distinguished, it is merely a narrow lobe whose free margin is continuous with the inner margin of the wing.

In the Hepialidæ the jugum, though homologous with the fibula, differs from it in shape and method of functioning. The difficulty in the way of deriving the Hepialidæ from ancestors with a fibula disappears if a process similar to that which is known to take place in the Nepticulidæ is postulated. The jugum, in accordance with this view, would be considered a development in another direction from the posterior lobe of the fore wing in a more or less reduced condition.

The fact that a fibula of identical structure, though showing some variation in function, is present in three different groups, two of which, the Micropterygidæ and Rhyacophilidæ, are primitive and approach one another closely in other char-

acteristics of the wings, indicates that it is a persistent primitive character handed down from the common ancestor. The Nepticulidæ show marked specialization and are the end of a line of development, having given rise to no other group. Though they are not apparently to be easily or directly derived from any existing group, the possession of this primitive character undoubtedly allies them more closely to the Micropterygidæ than to any other Lepidoptera, and also indicates trichopterous affinities. However, the possession by Micropterygidæ and Nepticulidæ of this character of primitive Trichoptera, while it indicates relationship to Trichoptera, need not be taken as a basis for regarding them as trichopterous insects, because as shown for Nepticulidæ, it has disappeared as a functional structure in males even of the less specialized genera, and its function has been taken over by a single-spined frenulum of a character typical of the males of the more specialized Lepidoptera. That is, the Nepticulidæ retain evidence of descent in the form of a fibula, but they have progressed far enough in the lepidopterous direction to have developed a distinctly lepidopterous structure. The undoubted relationship between the Nepticulidæ and the Micropterygidæ indicates that the Micropterygidæ are without doubt also lepidopterous, but being a more primitive group, have not traveled thus far toward the usual lepidopterous type in respect to mode of uniting the wings.

In Rhyacophilidæ and other groups of the Trichoptera, in Micropterygidæ, Nepticulidæ and many of the more primitive Frenatæ (Figs. 1, 2, 5, 4a, 8), there is a series of slightly curved stiff spines on the costa of the hind wing near the base, which lie against one of the anal veins of the fore wing, or catch into a similar series on the fore wing, or lie in the fold of the fibula, and aid in holding the wings together. These spines lie beyond the costal sclerite, not on it, as do the true frenulum spines. They are proximal to the humeral vein in forms where this vein is present. This series of spines is without doubt homologous in the various groups in which it occurs; it may be present in addition to other means of holding the wings together, or it may be the only method of insuring united action of fore and hind wings. It may be functional in females, while in the males of the same species its function has been taken over by some other structure. Thus in Nepticulidæ (Braun, '17),

these costal spines are functional in females, but in the male, where there is a single spined frenulum, they are rarely preserved with the same structure and function. In Nepticulidæ when functional, they are larger and stronger than in any other Lepidoptera (except perhaps *Opostega*); they are decidedly stronger than in the Micropterygidæ. The spines are present in several of the more primitive frenate lepidopterous groups, often in combination with other primitive characters, and sometimes persist in more specialized groups. In the females of many groups of Lepidoptera this is the only method of insuring the united action of the fore and hind wings. These spines are present in females in Prodoxidæ, Adelidæ and Incurvariidæ, together with a few weak and useless short spines in the position of the frenulum. Homologous structures much modified and without function of holding may be distinguished in the males in these families, together with a well developed single-spined frenulum. In many genera of *Lyonetiidæ* they persist particularly in the female where there is also a functional frenulum, and they may also be distinguished as definite structures in the male, different from the rest of the scale covering of the wing. It is questionable whether they are functional except in rare instances in this family.

The possession of the row of costal spines by many of the Trichoptera and by more primitive Lepidoptera indicates that it is a persistent primitive character, and as such indicates common descent of the two groups. The preservation of these spines in many frenate Lepidoptera is one of the few connecting links between them and the Micropterygidæ.

The series of costal hooks — the hamuli — which have developed in the more specialized families of Trichoptera as a means of locking the fore and hind wing together, is a specialization not found in the Lepidoptera.

The true frenulum spines are situated on the costal sclerite of the hind wing. Although structures homologous with a frenulum, consisting of several stiff spines on the costal sclerite of the hind wing are found in some of the more specialized Trichoptera, the frenulum in its specialized form, culminating in the single-spined frenulum with the well developed frenulum hook of the male, is a distinctly lepidopterous development. In most Trichoptera, in Micropterygidæ, in females of Nepticulidæ, in females of *Prodoxus, Adela,* etc. (Figs. 1, 2, 5, 4a, 8),

there are merely hairs or weak functionless setæ on the frenulum-bearing area: in these the function of holding the wings together is performed by some other structure. In the males of some of these, viz., Nepticulidæ, *Prodoxus*, *Adela*, etc., there is a strong single-spined frenulum, formed by the fusion of several spines, in some instances of as highly specialized a character as is found in any Lepidoptera. These forms furnish no evidence of the phylogenetic process of development of the frenulum or frenulum hook, but such evidence is furnished by the condition of the frenulum in some members of several groups which conserve other primitive characters. In Cossidæ and Megalopygidæ the frenulum is in a rudimentary condition, consisting of a bunch of spines, and in the females of many moths it consists of two or several spines. Of the process of transition from more primitive modes of holding the wings together to a functional frenulum, we have very little evidence. In this connection, the condition found in *Pronuba* is significant. In the female *Pronuba yuccasella* all except the two most proximal of the row of costal spines have become flattened and scale-like, and these two remaining spines are larger than any of the corresponding series found in *Prodoxus*, which is an allied, though more generalized genus. In addition in the female *Pronuba* the beginnings of a true frenulum are shown, consisting of a tuft of short, weak spines at the distal end of the costal sclerite in the same position as the frenulum of the male. There is also an inwardly projecting row of scales from the costa of the fore wing, apparently the beginning of a frenulum hook, which is present in the male. The female frenulum is not long enough to reach this row of scales, which is, however, easily reached by the two strong costal spines, which may thus *function* as a frenulum before the true frenulum has reached a sufficient size to be functional. These two spines are not present in the male *Pronuba*, which has a single-spined frenulum. In the Nepticulidæ there is no stage in the development of the frenulum intermediate between the minute functionless spines of the female, and the strong single-spined frenulum of the male. However, the fact that functional costal spines and frenulum are occasionally present at the same time, indicates that the costal spines retain their function up to the time that it is taken over by the frenulum. In the Cossid, *Prionoxystus robiniæ*, where the frenulum is rudimentary in both sexes, the

underside of the inner margin of the fore wing hooks against a strong ridge along the costa of the hind wing.

It is apparent then that a functional frenulum has originated independently in the Lepidoptera, and that it is not a primitive character derived from the ancestral lepidopterous stalk.

From the facts as above stated, it is equally apparent that the transition from more primitive modes of holding the wings together has taken place within the Lepidoptera, although in most cases the intermediate stages have not been preserved. That the frenulum originated independently several different times at least in the Lepidoptera is shown, first, by the fact that it appears in the Nepticulidæ, which is an end group not derived from or related to the frenate Lepidoptera; second, by the fact that it takes the place of costal spines in *Pronuba;* third, by the specialized condition of the frenulum in the males of certain groups, the females of which have a very rudimentary frenulum; fourth, by its rudimentary condition in other comparatively primitive groups, such as the Cossidæ, where there is no evidence of costal spines or similar holding structures, and the transition stage has been bridged by a very different means. It may have originated independently in other families, but we are without direct evidence to this effect; similarly it may have disappeared independently as is shown for example by its presence in *Euschemon* only, in the Hesperidæ.

The significant phylogenetic feature in the development of the frenulum is its appearance in the Nepticulidæ which is the end of a line of development, and which is related to Micropterygidæ and must be regarded as derived from them, and its independent appearance in the group usually known as the Frenatæ. No similar course of development is to be witnessed in the Trichoptera. The evidence for phylogeny derived from the frenulum in my view points unmistakably to the conclusion that the branch of the ancestral stem which produced Micropterygidæ and Nepticulidæ must also have given rise to the rest of the Lepidoptera and hence all should be included in one order.

(*c*) *Distribution of Fixed Hairs.*

A character, which when present, may without doubt be regarded as a persistent primitive character is the presence of the fixed hairs upon the wing surface. These are characteristic

of the Trichoptera, the Micropterygidæ and certain other of the more primitive families of the Lepidoptera, Nepticulidæ, Hepialidæ, Incurvariidæ, etc., where they are distributed over the entire wing surface, but even in these most plentiful on the underside of the fore wing near the dorsal margin. In many Lyonetiidæ, e. g., *Hieroxestis*, *Oinophila*, *Coptodisca*, besides the fixed hairs on the underside near the inner margin, there is a patch in the middle of the fore wing near the base; in *Tischeria* and *Opostega*, there are additional scattered fixed hairs on the wing surface. In other groups the fixed hairs are confined to the under side of the fore wing near the base of the dorsal margin, with the rare presence of such hairs on other parts of the wing, e. g., in *Tineola*. The very fact that the fixed hairs are most numerous in the most primitive groups, tending to become scattered and later confined to definite areas of the wing, and finally persisting only in a limited area on the underside of the fore wing, where they may function to a slight degree in holding the wings together in flight, shows that while taken in connection with other characters, their presence may indicate a comparatively primitive condition of the forms possessing them, the character is not one upon which a taxonomic division can be made.

III. Summary and Conclusions.

The discussion of wing structure in Lepidoptera has dealt chiefly with those characters which have been handed down from the common ancestor of both Lepidoptera and Trichoptera, and which have been preserved without modification in the most primitive Lepidoptera, but which have undergone more or less far-reaching modification in all other groups of Lepidoptera. In many instances the steps in the process of modification have been traced, and it has been possible to identify these characters in their modified form in many of the more primitive groups of frenate Lepidoptera. These changes in structure have sometimes been correlated with changes in function of certain parts of the wing or with the taking over of a particular function by a different organ.

The conclusion reached from a study of certain features of venation is that the Micropterygidæ are not as sharply separated from the rest of the Lepidoptera as might be inferred from a

comparison made only with more specialized groups of Lepidoptera. The modifications which are shown in the more primitive groups of frenate Lepidoptera have their beginnings in the Micropterygidæ themselves. In addition we have the evidence given by the Nepticulidæ, which combine in one group, certain characters found in the Frenatæ, with characters belonging to the Micropterygidæ and in the manner of specialization of certain characters of venation diverge from all other Lepidoptera, paralleling what occurs in some Trichoptera. The existence of these *divergent* groups, the Frenatæ and the Nepticulidæ, both of which are derived from Micropterygidæ, is conclusive evidence of the lepidopterous character of their common ancestor, the Micropterygidæ, even if we do not take into consideration such features of the Micropterygidæ as the character of the mouth-parts and the scale covering of the wings, which unmistakably stamp them as lepidopterous.

The conclusion drawn from a study of the various modes of holding the wings together in flight in the Lepidoptera, is that in the more primitive groups of Lepidoptera, including the Micropterygidæ, certain trichopterous structures are retained and are functional, but in higher groups are modified or disappear and their function is taken over by other wing structures, chief of which is the frenulum. The frenulum in its specialized form is shown to have had its origin in the Lepidoptera and to have developed independently in several widely separated groups.

Certain general phylogenetic and taxonomic conclusions follow from these studies. The Micropterygidæ are close to the common ancestor of both Lepidoptera and Trichoptera, but are true Lepidoptera. From them the remaining Lepidoptera have been derived, not from a single line of descent, but from several divergent lines, one of which is represented by the Nepticulidæ alone; a second line by the Hepialidæ, with the Prototheoridæ apparently forming a link between it and the Micropterygidæ, and to which the Cossidæ show some degree of relationship; a third much branched line includes the frenate Lepidoptera, of which some members such as the Prodoxidæ, Incurvariidæ, etc., conserve some of the trichopterous characters of their ancestry and must therefore be regarded as the most primitive of the Frenatæ.

IV. REFERENCES.

Braun, Annette F. 1917. Nepticulidae of North America. Trans. Am. Ent. Soc., Vol. XLIII, pp. 155–209.

Busck, August. 1914. On the Classification of the Microlepidoptera. Proc. Ent. Soc. Wash., Vol. XVI, pp. 46–54.

Chapman, T. A. 1896. Studies in Pupae. Trans. Ent. Soc. London.

Comstock, J. H. 1918. The Wings of Insects. The Comstock Publishing Co., Ithaca, pp. XVIII+430.

Kellogg, V. L. 1894. The Taxonomic Value of the Scales of Lepidoptera. Kansas Univ. Quart., Vol. III, No. 1, pp. 45–89.

MacGillivray, A. D. 1912. The Pupal Wings of Hepialus Thule. Ann. Ent. Soc. Am., Vol. V, pp. 239–245.

Meyrick, E. 1912. Lepidoptera Heterocera, Fam. Micropterygidae. Genera Insectorum, 132 me Fascicule.

Meyrick, E. 1917. Descriptions of South African Microlepidoptera, Annals South African Museum, Vol. XVII, pp. 1–21.

Mosher, Edna. 1916. A Classification of the Lepidoptera based on Characters of the Pupa. Bull. Ill. State Lab. Nat. Hist., Vol. XII, Art. 2.

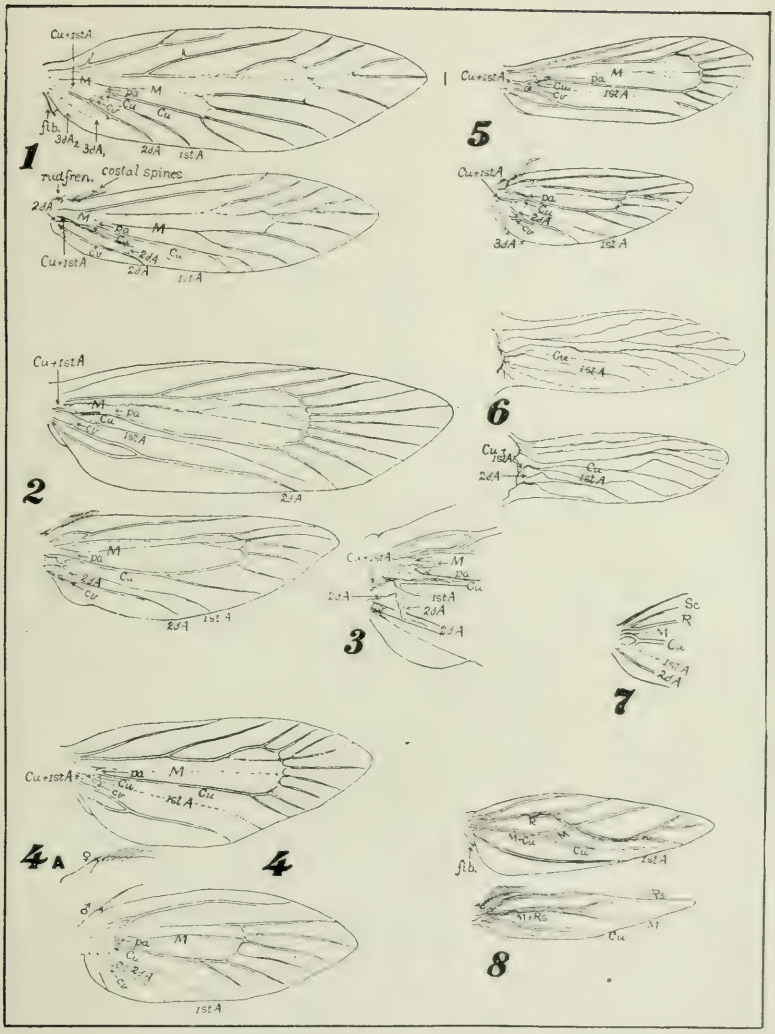
Tillyard, R. J. 1918. The Micropterygidae not of the Jugate Type. Ent. News, Vol. XXIX, p. 90.

Tillyard, R. J. 1919. A Further Note on the Wing-Coupling Apparatus in the Family Micropterygidae. Ent. News, Vol. XXX, p. 168.

Ulmer, George. 1907. Trichoptera. Genera Insectorum, 60me Fascicule.

EXPLANATION OF PLATE XXIX.

Fig. 1. Wings of *Epimartyria auricrinella.*
Fig. 2. Wings of *Prodoxus quinquepunctellus*, female.
Fig. 3. Base of hind wing of *Prodoxus quinquepunctellus*, female.
Fig. 4. Wings of *Cyanauges cyanella*, male; 4a, base of costa of hind wing of female.
Fig. 5. Wings of *Adela bella*, female.
Fig. 6. Trachcation of pupal wings of *Prodoxus quinquepunctellus.*
Fig. 7. Base of fore wing of *Renia flavipunctalis.*
Fig. 8. Wings of *Ectoedemia heinrichi*, female.



Annette F. Braun

THE LIFE HISTORY AND EARLY STAGES OF PLATYMETOPIUS HYALINUS OSB.,* A JAPANESE MAPLE LEAF-HOPPER IN NEW JERSEY.

By Edgar L. Dickerson and Harry B. Weiss,
New Brunswick, N. J.

For the past several years the writers have noted this species as occurring more or less abundantly on Japanese maple (*Acer palmatum* Thunb.) in various places in New Jersey, principally South Orange, Plainfield, Springfield, Irvington and Rutherford. During the summer of 1918 it was very abundant at Freehold, N. J., on a form of Norway maple (*Acer platanoides* L. var. *globosum* Nich.) and the following notes are the results of observations made at that locality.

The species overwinters in the egg stage, each egg being deposited singly just under the bark close to a bud on the recently made growth of the twig. The egg is firmly embedded in the tissue which becomes brownish and somewhat hard adjoining it. The outer bark over the egg is raised and somewhat cracked and a crack is also present where the egg is inserted. Sometimes the end of an egg protrudes slightly. The egg is inserted so that its long axis is more or less at right angles to the tissue and a favorite place for deposition is the thickened part of the twig around the buds. Sometimes eggs were found in groups of two to five each egg being separated from the other, however, by considerable tissue.

At Freehold, N. J., hatching took place about the first of June and continued for almost a month. As late as early July it was possible to find first stage nymphs. From eggs hatching the first few days in June, adults appeared the first few days of July, showing that about one month is necessary for the development of the five nymphal stages. This is probably the maximum time and would be shortened by very warm weather. On account of the uneven hatching of the eggs, it is possible to find all nymphal stages and adults present during the first part of July. By the end of July practically all of the nymphs have matured and at this time and during the first of August the adults are most plentiful. Over-

* Identified by E. P. Van Duzee.

wintering eggs are then deposited. The nymphs feed on the lower leaf surfaces and seem to prefer the shaded portions of the tree. The adults are very active, move readily when the leaves are disturbed and when numerous their activity results in sounds like rain falling on the leaves.

Egg—Length 0.9 mm. Greatest width 0.18 mm. Translucent, subelliptical, somewhat flattened and not quite cylindrical, tapering slightly to both ends, one end rounded, the other end, at the surface of the tissue, truncate.

First Nymphal Stage—Length, including anal processes, 1.1 mm. Width of head, including eyes, 0.29 mm. Elongate-elliptical; very light yellowish white; beginning just behind the eyes there is a reddish-brown, lateral margin varying in width and extending dorsally on prothorax, posterior margin of thorax and anterior margin of abdomen and on some of posterior abdominal segments (interrupted in some specimens); antennæ slightly longer than body; head extending forward, triangular, obtusely angled in front, sides slightly rounded; eyes lateral, prominent; insect widest across eyes; sides of body slightly rounded and tapering to posterior end of abdomen; posterior end of abdomen divided into two minute, spine-like processes; abdominal lateral row of hairs similar to row on second stage; (dorsal hairs not apparent); rostrum extending to beyond bases of second pair of legs; indications of spines on tibia.

Second Nymphal Stage—Length, including anal processes, 1.85 mm. Width of head, including eyes, 0.36 mm. Shape narrow, more elongate than that of first stage. Color varies from sordid white to light yellow. Lateral reddish-brown margin somewhat similar to that of first stage, but varying and somewhat broader. Antennæ three-fourths length of body. Head similar to that of first stage; sides of thoracic segments rounded; metathorax slightly longer than lengths of pro- and mesothorax combined; broadest across metathorax; abdomen slightly narrow at base, widening to second abdominal segment and gradually tapering to posterior part; spine-like processes one and one-half times as long as last abdominal segment and bearing several hairs; each abdominal segment bears two dorsal and two subdorsal and in addition the last three segments two lateral hairs; rostrum extending to between bases of second pair of legs; two rows of hair-like spines on outer margins of hind tibia.

Third Nymphal Stage—Length, including anal processes, 2.9 mm. Width of head, including eyes, 0.44 mm. Somewhat similar to preceding stage; eyes more prominent; lateral reddish-brown markings more extended, in some specimens much extended on dorsal surface leaving a dorsal, median band of ground color of varying width (markings vary considerably in different individuals); anterior margin of head slightly more angulate; posterior margin of prothorax arcuate, outer posterior angles margined; mesothorax twice as long at sides as at middle; metathorax twice as long as pro- and mesothorax combined, posterior

margin subtruncate, scarcely longer at sides than at middle; abdominal hairs similar to those of fifth stage nymph; posterior abdominal spine-like processes equal in length to the two posterior abdominal segments; rostrum extending to between bases of second pair of legs.

Fourth Nymphal Stage—Length, including anal processes, 4.1 mm. Width of head, including eyes, 0.58 mm. Shape somewhat similar to that of fifth stage; dorsal and lateral reddish-brown markings somewhat similar to those of preceding stage, but more diffused, in some specimens extending further medially on dorsal surface of head and some of body segments; antennæ about one-half length of body; eyes prominent, lateral, extending slightly posteriorly; anterior margin of head subacute, sides slightly rounded; prothorax rounded in front to conform to posterior margin of head, posterior margin slightly curved and slightly wider than anterior margin; mesothorax with lateral margins decidedly elongate covering two-thirds of metathoracic lateral margins; metathorax with lateral margins somewhat elongate, covering part of first abdominal segment; abdomen broadest across second segment gradually tapering to end; length of posterior abdominal spine-like processes more than combined lengths of last two abdominal segments; spine-like processes bearing long hairs; abdominal hairs similar to those of fifth stage nymph; rostrum extending almost to bases of second pair legs; few, minute spines on legs; hind tibial spines similar to those of fifth stage.

Fifth Nymphal Stage—Length, including anal processes, 5.5 mm. Width of head, including eyes, 0.78 mm. Elongate-narrow; vertex acutely pointed and abdomen gradually tapering from anterior portion to apex; color sordid white with dorsal and lateral surfaces and wing-pads mottled with a number of orange-yellow spots often margined with interrupted reddish-brown lines, spots vary in size and some tend to form one or two dorsal rows; antennæ more than twice the length of the head, situated on front just below eyes; head acutely pointed, posterior margin arcuate, eyes prominent, extending backward, forming outer posterior angles; head as long as width of broadest portion of head across eyes; prothorax rounded in front to conform to the posterior margin of head, posterior margin slightly curved, slightly wider than widest portion of head across eyes; mesothorax about as wide as prothorax; median portion of mesothorax about one-half as long as width, sides somewhat shorter; wing-pads long, narrow and extending to posterior margin of first abdominal segment. Metathorax about as long as mesothorax; wing-pads extending slightly beyond those of mesothorax; abdomen widest across anterior end and gradually tapering to last segment which is terminated by two, long, spine-like processes, which equal in length the combined lengths of the last three segments; each abdominal segment bears near its posterior margin two dorsal and two subdorsal and beginning with the third segment, two additional lateral, fine, long hairs which are equidistant; posterior spine-like processes also bear a number of fine, long, hairs; ventral surface and legs sordid white; rostrum extending beyond bases of first pair of legs; hind tibia bearing a row of hairs on inner margin and a double row of spine-like hairs on outer margins; few minute spines on legs.

ADULT—*Platymetopius hyalinus* Osborn. This was described by Osborn in 1900 (Ent. News, vol. XI, p. 501) from five females and four males collected in Washington, D. C., June, 1897, by Mr. J. S. Hine, who stated that they were very abundant upon an introduced species of maple. As this description is available to most entomologists, there is no need to repeat it here. It might be stated, however, that the insect can be recognized due to the fact that it is quite distinct from any other species of the genus occurring in this country. In Osborn's description it is characterized as follows: "Elytra hyaline with dark points and fuscous bands arranged, one subbasal, one median and one subapical. Face bright, sulphur-yellow, vertex, pronotum and scutellum yellow, with some infuscations or greenish washes. Length, female, 5.5 mm.; male, 4.25 mm."

Van Duzee, in his "Revision of the American Species of Platymetopius," (Annals Ent. Soc. Amer., vol. 3, 1910, p. 218), states that "this insect is quite aberrant in its genus by its uniformly whitish hyaline elytra crossed by three narrow fuscous bands. Prof. Osborn described it from a series taken from an imported tree at Washington, D. C., and strongly suspected that it might be an exotic form introduced from material added to the Botanical Gardens there. In that case it probably has become acclimated as Mr. C. W. Johnson has sent me a specimen he took near Philadelphia."

While Pennsylvania and the District of Columbia are the only localities listed in Van Duzee's Catalogue, it probably occurs in many other eastern places in view of the wide distribution of the Japanese maple as an ornamental tree. We believe that Prof. Osborn's surmise that this is an introduced species is correct and that it has been brought into this country on imported maples. This is quite possible in view of the fact that overwintering takes place in the egg stage in the twigs.

THE PREVALENCE OF PHORMIA AZUREA FALLEN (LARVA PARASITIC ON NESTLING BIRDS) IN THE PUGET SOUND REGION AND DATA ON TWO UNDESCRIBED FLIES OF SIMILAR HABIT.

By O. E. Plath.

(Together with Descriptions of the Two New Flies by C. H. T. Townsend and J. M. Aldrich.)

In two recent papers[1] the writer pointed out that the larvæ of *Phormia*[2] *azurea* Fallen habitually suck the blood of nestling birds, sometimes with fatal results, and that the adult flies, contrary to the opinion of most dipterists, are quite abundant, at least in the San Francisco Bay Region. Last summer (1918), while visiting Seattle, he had occasion to ascertain whether *Phormia azurea* Fallen also occurs in the Puget Sound Region and found that it is as frequent there as in the San Francisco Bay Region. During his stay at Seattle (June 15th to August 1st), fifty-four birds' nests were examined containing nestlings belonging to ten different species of birds. Of these fifty-four nests, thirty-three were infested by the larvæ of *Phormia azurea* Fallen,[3] one by those of a new species of *Phormia*, and six by those of a new fly belonging to the genus *Hylemyia* of the family Anthomyidæ. Drs. J. M. Aldrich and C. H. T. Townsend, of the United States Bureau of Entomology, have been kind enough to describe the two new flies, the descriptions being appended to this paper, and the two flies will hereafter be referred to as

[1] Plath, O. E. (a) Parasitism of Nestling Birds by Fly Larvae. The Condor, Vol. XXI (1919), pp. 30–39. (b) A Muscid Larva of the San Francisco Bay Region which Sucks the Blood of Nestling Birds. Univ. Calif. Publ. Zool., Vol. XIX (1919), pp. 191–200.

[2] A synonym of *Protocalliphora* which Dr. C. H. T. Townsend of the United States Bureau of Entomology considers more appropriate.

[3] A large number of specimens of this fly were sent to Dr. C. H. T. Townsend of the United States Bureau of Entomology who has informed me that the fly was correctly identified by Mr. C. W. Johnson (Cf. a. The Condor, Vol. XXI, p. 34. b. Univ. Calif. Publ. Zool., Vol. XIX, p. 194. Dr. Townsend has also called my attention to the fact that Coutant's fly (Cf. Coutant, A. F., The Habits, Life History, and Structure of a Blood-sucking Muscid Larva (*Protocalliphora Azurea*). Jour. Parasit., Vol. I, pp. 135–150) is not *Protocalliphora* (*Phormia*) *azurea* Fallen, as was claimed by Coutant, but *Phormia chrysorrhea* Meigen. This fact, Dr. Townsend thinks, may account for the disparity between Coutant's observations and mine (Cf. The Condor, Vol. XXI, p. 37. b. Univ. Calif. Publ. Zool., Vol. XIX, pp. 198–199).

Phormia metallica Townsend[4] and *Hylemyia nidicola* Aldrich. The frequency with which the larvæ of *Phormia azurea* Fallen were encountered in birds' nests, and the number of larvæ and pupæ per nest, is shown by the following tables:

TABLE I.

Species of Bird	Nests examined	Infested nests	Uninfested nests	Infestation
Nuttall Sparrow (*Zonotrichia leucophrys nuttalli* Ridgway)	3	3	0	100%
Rusty Song Sparrow (*Melospiza melodia morphna* Oberholser)	2	2	0	100%
Willow Goldfinch (*Astragalinus tristis salicamans* (Grinnell)	2	2	0	100%
Oregon Towhee (*Pipilo maculatus oregonus* Bell)	1	1	0	100%
Russet-backed Thrush (*Hylocichla ustulata* (Nuttall)	5	4	1	80%
Western Robin (*Merula migratoria propinqua* (Ridgway)	25	18	7	72%
Cedar Waxwing (*Ampelis cedrorum* (Vieillot)	3	1	2	33%
Yellow Warbler (*Dendroica aestiva* (Gmelin)	5	1	4	20%
Cliff Swallow (*Petrochelidon albifrons* Say)	7	1	6	14%
English Sparrow (*Passer domesticus* Linnaeus)	1	0	1	0%
Totals	54	33	21	61% ;Average

[4] A species closely related to *Phormia chrysorrhea* Meigen, the latter, according to Dr. Townsend, being synonymous with *Phormia sordida* Zetterstedt and *Phormia splendida* Macquart.

TABLE II.

Species of Bird	Larvae in Each Nest	Totals	Larvae per Nest
Nuttall Sparrow (*Zonotrichia leucophrys nuttalli* Ridgway)	39, 40, 87	166	55
Rusty Song Sparrow (*Melospiza melodia morphna* Oberholsder)	52, 55	107	53
Cliff Swallow (*Petrochelidon albifrons* Say)	47	47	47
Oregon Towhee (*Pipilo maculatus* Bell)	45	45	45
Willow Goldfinch (*Astragalinus tristis salicamans* (Grinnell)	28, 59	87	43
Yellow Warbler (*Dendroica aestiva* (Gmelin)	39	39	39
Western Robin (*Merula propinqua* (Ridgway)	7, 11, 15, 16, 18, 18, 21, 23, 26, 27, 27, 29, 37, 39, 40, 43, 72, 138	607	33
Russet-backed Thrush (*Hylocichla ustulata* Nuttall)	22, 27, 28, 31	108	27
Cedar Waxwing (*Ampelis cedrorum* (Vieillot)	2	2	2
Totals		1208	36 Average

All of these nests, excepting eight, were located in shrubs and trees three to twenty feet above ground, while the remaining eight came from an altitude of about forty feet. Seven of the latter (the Cliff Swallow nests) were taken from below the eaves of a two story building on the campus of the University of Washington, and the remaining one (that of the English Sparrow) from a box near the top of a high telephone pole. The comparatively small percentage of infestation of these eight nests might of course be a coincident, but it is perhaps more probable that it was due to the location and structure of the nests.

The thirty-three nests infested by the larvæ of *Phormia azurea* Fallen contained 111 nestlings. Although many of the larvæ taken from these nests were gorged with blood, only two

of the 111 nestlings died. That there were no more fatalities is perhaps to be explained by the fact that more than half of the thirty-three infested nests were those of comparatively large birds, the Western Robin and the Oregon Towhee.

The nest infested by the larvæ of *Phormia metallica* Townsend was that of a Western Robin and contained three nestlings. When the latter took wing, twenty-six larvæ were taken from the nest. The larvæ pupated in a few days and both larvæ and pupæ looked so much like those of *Phormia azurea* Fallen that the writer was unaware that he was dealing with a new fly until the adults emerged. From the facts at hand it seems probable that *Phormia metallica* Townsend, both as larva and adult, is similar in habit to that of its near relative, *Phormia chrysorrhea* Meigen.

The six nests infested by the larvæ of *Hylemyia nidicola* Aldrich offered an entirely different aspect. When discovered four of them contained the remains (only bones and feathers) of nine, nearly full-fledged nestlings. From these four nests, 283 pupæ were taken nearly all of which later hatched. The remaining two nests infested by the larvæ of *Hylemyia nidicola* Aldrich were those of a Cliff Swallow and a Yellow Warbler and contained one and five dead nestlings respectively. In these two nests the larvæ were still at their repast. Fifty-nine larvæ were picked from the outer surface of the six dead birds, though many more could undoubtedly have been obtained from within the nestlings. None of the six nests infested by the larvæ of *Hylemyia nidicola* Aldrich contained any living nestlings when discovered, but judging by the small number of dead birds in most of the nests, it seems possible that some of the nestlings may have survived.

The larva of *Hylemyia nidicola* Aldrich is much smaller than that of *Phormia azurea* Fallen and measures about 8 mm. in length and 2 mm. in width when mature. It apparently is not blood-sucking in habit like the larvæ of *Phormia azurea* Fallen, *Phormia chrysorrhea* Meigen, and other Muscidæ. The pupa[5] measures about 5 mm. in length and 2.5 mm. in width and is of a glossy, golden-brown color.

[5] It is identical in size and appearance with the seventy-one secured near Berkeley, California, the preceding summer (Cf. a. The Condor, Vol. XXI, pp. 36–37. b. Univ. Calif. Publ. Zool., Vol. XIX, pp. 196–197).

There are only two possible explanations in regard to the relation existing between the dead nestlings and the presence of the larvæ of *Hylemyia nidicola* Aldrich. The first is that the young birds died from some cause or other and that the adult flies were then attracted by the odor of the decomposing nestlings to deposit their eggs, or maggots, on them. The second explanation would be that the eggs, or maggots, were deposited on, or near, the young birds while the latter were still alive, the larvæ subsequently causing the death of the nestlings by penetrating into their body. It has been known for some time that the larvæ of certain species of flies belonging to the genera *Hylemyia* and *Mydaea* of the family Anthomyidæ attack nestling birds in Central and South America,[6] and the second explanation is therefore not an improbable assumption. Should further investigations prove that the larvæ of *Hylemyia nidicola* Aldrich do attack living nestlings, as now seems probable, then it will be important to determine the range and bring this fly under control if we are not to suffer considerable loss among our wild birds.

As regards subcutaneous parasitism of nestling birds by fly larvæ, I should like to relate an interesting experience I had at Seattle, last summer. During my investigations I came across a nest containing six Willow Goldfinches which were nearly old enough to leave the nest. One of these nestlings had a patch of yellow on its head instead of being of the ordinary color. I turned this bird over to a lady in Seattle to have it reared with a brood of canaries. Two or three days later my attention was called to the fact that some of the feathers on the bird's head were standing up and that the young bird was constantly scratching its head. Upon examining the bird I noticed three small holes, one on top and two at the side of its head. Near the opening of each of these holes the anal end of an active fly larva was visible. The larvæ were extracted with considerable difficulty by means of a pair of scissors and forceps, and were about 5 mm. in length and 2 mm. in width.

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[6] Cf. (1) Townsend, C. H. T., (a) The Grass-quit Bot, an Anthomyiid Parasite of Nestling Birds in Jamaica. Jour. Inst. Jamaica, Vol. II, pp. 173–174. (b) *Mydaea spermophilae* n. sp. (Larva Parasitic on Nestling Birds). Trans. Amer. Ent. Soc., Vol. XXII, p. 79. (2) Nielsen, J. C., (a) *Mydaea anomala* Jaenn., a Parasite of South-American Birds. Vidensk. Meddel. fra Dansk Naturhist. Foren. Bd. 63 (1912), pp. 195–208. (b) On Some South-American Species of the Genus *Mydaea*, Parasitic on Birds, *ibid.* Bd. 65 (1913), pp. 251–256.

They were similar in appearance to the immature larvæ of *Phormia azurea* Fallen, but showed no blood in their intestines. I tried to rear these three larvæ, but all three died before pupating. The young goldfinch completely recovered from the rather severe operation and is still living (March, 1919).

The study of birds' nests from the viewpoint of the entomologist and parasitologist seems thus far to have been rather neglected. While examining Cliff Swallow nests below the eaves of a two-story building on the campus of the University of Washington, I found them so thickly infested by bed bugs[7] that I preferred to leave the remaining nests alone. Another blood-sucking insect that seems to use birds' nests as a favorable breeding place is the flea. I had encountered numerous flea larvæ in birds' nests near Berkeley, California, the preceding summer (1917), but when I saw the almost incredible multitude of flea larvæ contained in a single sparrow nest which was taken from a box near the top of a high telephone pole at Seattle, I was amazed. In addition to the parasites which I have spoken of as inhabiting birds' nests, two or three others were mentioned in one of my recent papers,[8] and this number will undoubtedly be increased. These facts make it evident that birds' nests offer a fruitful field of investigation for the professional parasitologist.

[7] Very probably *Oeciacus* (*Acanthia*) *hirundinis* Jen., a species closely related to the common bed bug, *Cimex* (*Acanthia*) *lectularia* Linnaeus, but more slender than the latter.

[8] Cf. The Condor, Vol. XXI, pp. 35–36.

Description of the New Species of *Phormia*.

By C. H. T. Townsend,
United States Bureau of Entomology, Washington, D. C.

Phormia metallica n. sp.

Length, 7 to 8.5 mm. Twenty-eight specimens, all females; eight pinned from New Hampshire, Virginia, Illinois, Wisconsin; and twenty, of which ten are alcoholic, from Puget Sound, Washington State, reared by Mr. O. E. Plath from maggots taken from nests containing young birds.

Female vertex one-sixth to one-fourth head width. Head brownish, thinly olive-grayish pollinose, with more or less of a brassy tinge. Viewed obliquely from below the whole face appears blackish, with a conspicuous golden spot at upper end of both parafacilia. Antennæ wholly blackish or brown, the third joint one and one-half to two times as long as second. Palpi fulvous to rufous, the tips fuscous. Thorax and scutellum dark metallic greenish-black to bright cupreous or brassy-green, silvery to olive-gray pollinose, leaving three nearly equal and rather heavy vittæ of the ground color. There is a faint narrow dark vitta barely visible in front close on each side of the median vitta in some specimens. Abdomen metallic dark bluish-green to bright cupreous or golden-green, showing thin silvery pollen coat in certain lights, the anal segment always cupreous to golden-green. Legs blackish. Wings clear. Tegulæ white to buff-yellow.

Holotype from Franconia, New Hampshire.

There is a well marked difference in the two forms here described as one species. The typical form, represented from all the above localities, is the darker one, with only the anal segment golden-green, and the tegulæ white. The vertex is about or nearly one-fourth head width, and the length is 7 to 8.5 mm. Thoracic pollen silvery.

The other form, represented by three New Hampshire and four Puget Sound specimens, has the abdomen wholly cupreous to golden-green, the anal segment being concolorous; the thorax and scutellum cupreous to brassy-green, almost the same shade as abdomen; and the tegulæ deep buff-yellow. This form will perhaps prove to be a good subspecies, or it may even be specifically distinct. The front is narrower in this form, the vertex running from one-sixth to little over one-fifth head width, and the length is 7 to 7.75 mm. Thoracic pollen olive-gray.

The Puget Sound specimens, of both forms, have the third antennal joint about twice as long as second, the second joint

being moderately short. The eastern specimens, of both forms, have the second antennal joint longer, and the third joint only about one and one-half times as long as second.

The typical form was identified by Coquillett as *Calliphora splendida* Macquart, and specimens of the other form were included in the series so labeled by him. Macquart's specimen was from Galveston, Texas, and the size was given as five lines or 10 mm. The thorax and scutellum were stated to be black, the abdomen greenish-blue with tip golden. The first two antennal joints were said to be very short, and testaceous in color. Also the wings were said to be fuscous on costal border. On account of these discrepancies, I am unable to identify the present forms as Macquart's species, which appears certainly to be a synonym of *chrysorrhea* Meigen.

Description of a New Species of *Hylemyia*.

By J. M. Aldrich,
United States Bureau of Entomology, Washington, D. C.

Hylemyia nidicola n. sp.

Male—Deep black, with yellow halteres; calypters infuscated, almost black, with the fringe dark below.

Front hardly wider than lower ocellus; six pairs of frontal bristles, beginning at middle; frontal and facial orbits dark, not silvery, narrow; antennæ black, rather large, third joint reaching nearly to edge of mouth, twice as long as second, arista bare; face flat, edge of mouth very little protruding; bucca about one-eighth the eye-height, rather bristly; palpi and proboscis black, ordinary; back of head flat, with coarse black hair.

Thorax deep black, rather velvety above, with a trace of paler pollen at inner edge of humerus each side; two to three pairs of large anterior acrostichals, three posterior dorsocentrals, three sternopleurals; metanotum with gray pollen; pteropleura and hypopleura without hairs.

Abdomen black, with a faint, interrupted lighter pollinose cross-band on each segment and a median dark stripe; fifth sternite with deep excision and two long black lobes, which do not bear any striking bristles.

Genitalia rather small; first genital segment shining black, with about twenty small bristles; second segment subshining, with ordinary hairs directed backward; inner forceps united, short, beadlike, with two long hairs on each side near tip; outer forceps dark brown, shining, twisted, not long, rounded at tip.

Legs wholly black, without striking characters, pulvilli a little enlarged, brownish; front tibia with one or two bristles on outer hind

side; middle tibia with one on outer front, one on outer hind, and two on inner hind side; hind tibia with two on outer front, six on outer hind, three on inner hind, and a few cilia on basal half.

Wings uniformly blackish-brown; costal spine almost wanting; last section of fourth vein one and a half times the preceding.

Female—Color rather uniform dark gray; front almost one-third the head width; cruciate bristles present; abdomen uniform gray, subshining; chaetotaxy as in male. Calypters yellow, with pale fringe; wing not infuscated.

Length, 4 mm.

Locality, Seattle, Washington.

Type, male, allotype, female, and one paratype female, deposited in United States National Museum (Type No. 22131). Paratype male and female deposited in the California Academy of Sciences.

The species shows the usual characters of *Hylemyia*—sixth vein reaching wing-margin, scutellum with delicate hairs below, hind calypter not elongated. The bare arista would place it in *Phorbia* according to the prevailing system; but I agree with Malloch (in Trans. Amer. Ent. Soc., xliv, 305, 1918) that plumosity of the arista is not a generic character in this case and *Phorbia* cannot be maintained.

NOTES ON THE BIOLOGY OF THE CARABID GENERA BRACHYNUS, GALERITA AND CHLAENIUS.*

J. L. King, Harrisburg, Pa.

One of the most interesting and unexpected habits recorded of the *Carabidæ* centers about the egg-laying of certain species of the genus *Chlaenius*. In a family of beetles so decidedly terrestrial in their habits we are indeed surprised to find that certain members deposit their eggs in delicate mud or clay cells high above the ground on the leaves of trees and shrubs.

Dr. C. V. Riley in the Proceedings of the Entomological Society of Washington, I, 23, 1884, was the first to record this interesting method of oviposition through his observations of the egg cells of *Chlaenius impunctifrons* Say. He also stated in this note he had strong proof that *Chlaenius aestivus* Say, *Scarites subterraneus* Fab. and the genera *Dicaelus* and *Galerita* share with *C. impunctifrons* its singular mode of oviposition. However, after the publication of this note Riley does not seem to have given his proof that the beetles in question do deposit their eggs in earthen cells as does *C. impunctifrons* nor, as far as the writer is aware, do we have further mention of this anomalous method of oviposition occurring in the Carabidæ until a recent paper by Claassen in 1919.† In this paper we are given a description and figure of the mud cells of *Chlaenius impunctifrons*, the same species reared by Riley in 1884.

The writer first observed these eggs during the summer of 1917, but was not successful in rearing the larvæ which issued beyond the third instar. As all attempts to learn the identity of the cell builder proved fruitless the study was again taken up the following year with such success that it was proven *Chlaenius aestivus* Say was one of the cell builders, however, a marked difference in the form and placement of the cells led to the conclusion there were three species of cell builders living in the same habitat. Through careful rearing from eggs to adults this proved to be true as *Galerita bicolor* Drury and

* A paper on the life histories and biology of the beetles herein mentioned is in preparation by the author.

† Claassen, W. P., Life History and Biological Notes on *Chlaenius impunctifrons* Say. Annals Ent. Soc. Amer., XII, 95–99, Pl. VI. 1919.

Chlaenius impunctifrons Say were reared from the egg cells in question. After this other habitats were studied and by careful rearing of all the eggs found and obtaining eggs from beetles in captivity, it was also proven that *Chlaenius cericeus* Forst., *Chlaenius tricolor* Dej. and *Brachynus cyanipennis* Say. also deposit their eggs in mud or clay cells constructed by the female beetle.

The form, size and structure of the mud cells of these beetles seems to be distinct in each species and this, together with decided variation in the immediate location or placement of the cells, renders specific identification possible for most of the species studied with the exception of *Brachynus*.

The Mud Cells of Brachynus.

The mud cells of *Brachynus cyanipennis* Say (Plate XXX, Figs. 1 and 2) are somewhat crescentic or triangular in outline, rough in surface and measure about 2.25 mm. in length, that is, the longest axis. The cells of these beetles are commonly placed on the undersurface of loosely set stones, on dead twigs and plant stems; they may be placed singly or in groups of three to ten in number. In captivity the cells were sometimes constructed massed one upon the other in clusters of eighteen to twenty-five.

The Mud Cells of Galerita.

The mud cells of *Galerita bicolor* (Plate XXX, Fig. 3) are roughly triangular in outline or purse shaped and finely granular in surface. They are 5 mm. in length and 3.5 to 4 mm. in width. The cells of this species are placed singly on the under surface of smooth leaves, *Benzoin* and *Impatiens* being most frequented by the beetles in the habitat studied.

The Mud Cells of Chlaenius.

With *Chlaenius impunctifrons*, the species studied by Riley and Claassen, the mud cells (Plate XXX, Fig. 4) are almost always smoothly convex and oblong in outline, measuring about 3.5 mm. in length and 2.28 mm. in width. In the habitats studied it was noted that about ninety per cent of the cells of this species occur on living plants, the under surface of smooth leaves being most often selected by the beetles. The distance

above the surface of the ground at which the cells are placed varies from a few inches to seven feet or higher however, one to two feet is nearer the average.

Unlike the preceding species, *Chlaenius aestivus*, while often living in the same habitat as *C. impunctifrons*, rarely ever constructs her mud or clay cells on leaves. In the habitats studied, they were found almost exclusively on dead twigs, plant stems and the bark of trees and shrubs, the dead thorns of *Gleditsia* were much used in one habitat and in another locality they were occasionally found on the strands of a barbed wire fence. They are sometimes placed ten feet above ground.

The cells of *C. aestivus* (Plate XXXI, Figs. 1 and 2) are convex and oval in form, coarsely granular or rough in surface; length 3.75 to 4.5 mm., width 2.75 to 3 mm. The exit of the larva is effected by the breaking off of the lidlike flap, which covers one side of the cell.

The earthen egg cells of *Chlaenius cericeus* (Plate XXXI, Fig 4) are smooth in surface, 3.75 mm. in length, 2 mm. in width. In general shape they are somewhat triangular or purse shaped. The cells of this species have not been observed in nature, but in captivity the beetles placed their cells on stones and the lower parts of dead plant stems, all very near the surface of the moist soil.

The cells of *Chlaenius tricolor* are small, measuring about 2 mm. in length and 1.25 mm. in width. They are strongly rounded, oblong in outline, smooth in surface and along one side there is a distinct fold or flap which marks the point of closure. This species constructs her cells of fine clay-sand. The stems of slender grasses and sedges seem to be most frequented by the beetles. Cells were found in great abundance along the shore of the Susquehanna River at Harrisburg, Pa., on the common sedge *Eleocharis tenuis*.

Construction of the Mud Cell.

As far as the writer is aware, no one has yet noted how these cells are made. This has been observed by the author, but will be only mentioned in this preliminary note, it sufficing to state that the pellet of mud is collected by the beetle at and around the tip of the abdomen in such a way that the cell formed is in reality a mold of the caudal abdominal segments;

the lid of the cell being formed from a thin layer of mud which covers the dorsal portion of these segments. After the deposition of the egg the tip of the abdomen is withdrawn and is again used to bend down the dorsal flap or lid and close the cell, the lid of which is self sealing, because of the soft texture of the mud at the time of construction. Thus the mud cells of *Chlaenius* may be compared to a pouched envelope in form and mechanism. The folding flap and the sealing of the edge when the soft mud of the flap comes in contact with the opposite lip of the cell is not different in principle from that of a common envelope. The clay cells of *Chlaenius tricolor* (Plate XXXI, Fig. 3a) show this structure quite distinctly.

As concerns the number of cells made by an individual beetle, I have noted that *C. impunctifrons* may construct seven to twenty cells during one night and eighty-two cells in a season.

Feeding Habits of the Larvæ.

The cell building habit of these Carabids presents several interesting biological questions. Among these is one relative to the feeding habits of the issuing larvæ. As concerns this, there is but a single note by Claassen, Annals of the Ent. Soc. Amer., XII, 96, 1919. I quote the following:

"Various kinds of food were offered to the young larva (*of Chlaenius impunctifrons*); larvæ and pupæ of *Lymnaecia phragmitella* Stainton, larvæ of *Nonagria oblonga* Grote, *Arsilonche albovenosa* Goeze, and *Arzáma obliqua* Walk. Flies and fresh meat were also offered to the larva. At first the young larva fed somewhat on flies and on larvæ and pupæ of *L. phragmitella*, but it showed a decided preference for the little larvæ of *A. obliqua*.

During the second and third instar all other food was refused except larvæ of *A. obliqua*.

All the above mentioned Lepidoptera are inhabitants of Typha. *A. albovenosa* is an incidental surface feeder on the leaves; *L. phragmitella* lives in the heads of Typha, while *A. obliqua* and *N. oblonga* both begin their larval activities as leaf miners, later becoming solitary stem borers.

It is possible that the larvæ of *Chlaenius impunctifrons* feed altogether on the larvæ of *A. obliqua*. The former hatch

about the same time that the larvæ of the latter species leave the mines of the leaves of Typha to become stem borers. Thus while they are exposed they might easily fall prey to the Carabid larvæ."

From the above quotation it would seem that there is a possible relationship between the occurrence of the mud cells of *C. impunctifrons* on Typha and the food of the issuing larvæ as being the Lepidopterous inhabitants of Typha.

The writer believes that so far with all the known species of Carabidæ which deposit their eggs in earthen cells on plants, there is no correlation between the immediate location of the egg cells and the feeding habits of the issuing larvæ. He believes, therefore, that Claassen's statements are misleading and for *Chlaenius impunctifrons* points out the following reasons:

First, because *Chlaenius impunctifrons* is often found in abundance in habitats where Typha and its inhabitants are entirely wanting. Second, the larvæ of this species are not climbers, it being doubtful if they could climb the smooth leaves of Typha. As observed by the writer the larvæ either in captivity or in nature were never seen to climb and in their natural state have been observed at night running about among stones and debris on the muddy shores of the Susquehanna. In nature I have never observed the larvæ feeding, however, in captivity they were general feeders preying upon all soft bodied insects which were not too active to escape them. They fed greedily on small Lepidopterous larvæ (Gelechids and Geometrids) Collembola, termites, crippled flies and the larvæ and pupæ of several species of ants. The ant larvæ and pupæ were easily collected and proved an ideal food for the Carabid larvæ, consequently they were used as the chief food in rearing all the species mentioned in this paper, with the exception of Brachynus.

A further lack of such correlation between the place of egg laying and the feeding habits of the larvæ is shown in *Chlaenius aestivus* which deposits her eggs in cells on dead twigs, tree trunks and many other objects not supporting any forms of life at all. Lastly, in *Brachynus*, which genus also shares this cell building habit, we have parasitic larvæ, the hosts of which are often quite removed from the twigs, stems and stones on

which the egg cells are found. The larvæ of *Brachynus cyanipennis* mentioned in this paper, are parasitic on the pupæ of *Dineutes discolor*.

Parasites.

A number of minute Hymenopterous parasites have been reared from the egg cells of these Carabids. With *Brachynus* as high as fifty per cent of the eggs found in nature were parasitized by tiny winged and wingless Hymenoptera of the genus *Hoplogryon*. All parasites of *C. impunctifrons*, *C. aestivus*, and *C. tricolor* were winged. In one habitat studied the eggs of *C. tricolor* were parasitized to the extent of twenty-five per cent, by a minute Hymenopteron, *Prosacantha caraborum* Riley, which is a common parasite of several species of *Chlaenius*.

Acknowledgments.

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EXPLANATION OF PLATES.

Plate XXX.

(Figures seven diameters.)

Fig. 1. Masses of mud cells of *Brachynus cyanipennis*. Cells made by beetles in captivity.

Fig. 2. Mud cells of *Brachynus cyanipennis* as found in nature on the under surface of a stone.

Fig. 3. Mud cell of *Galerita bicolor* on the under surface of Impatiens leaf.

Fig. 4. Mud cell of *Chlaenius impunctifrons* on under surface of Benzoin leaf.

Plate XXXI.

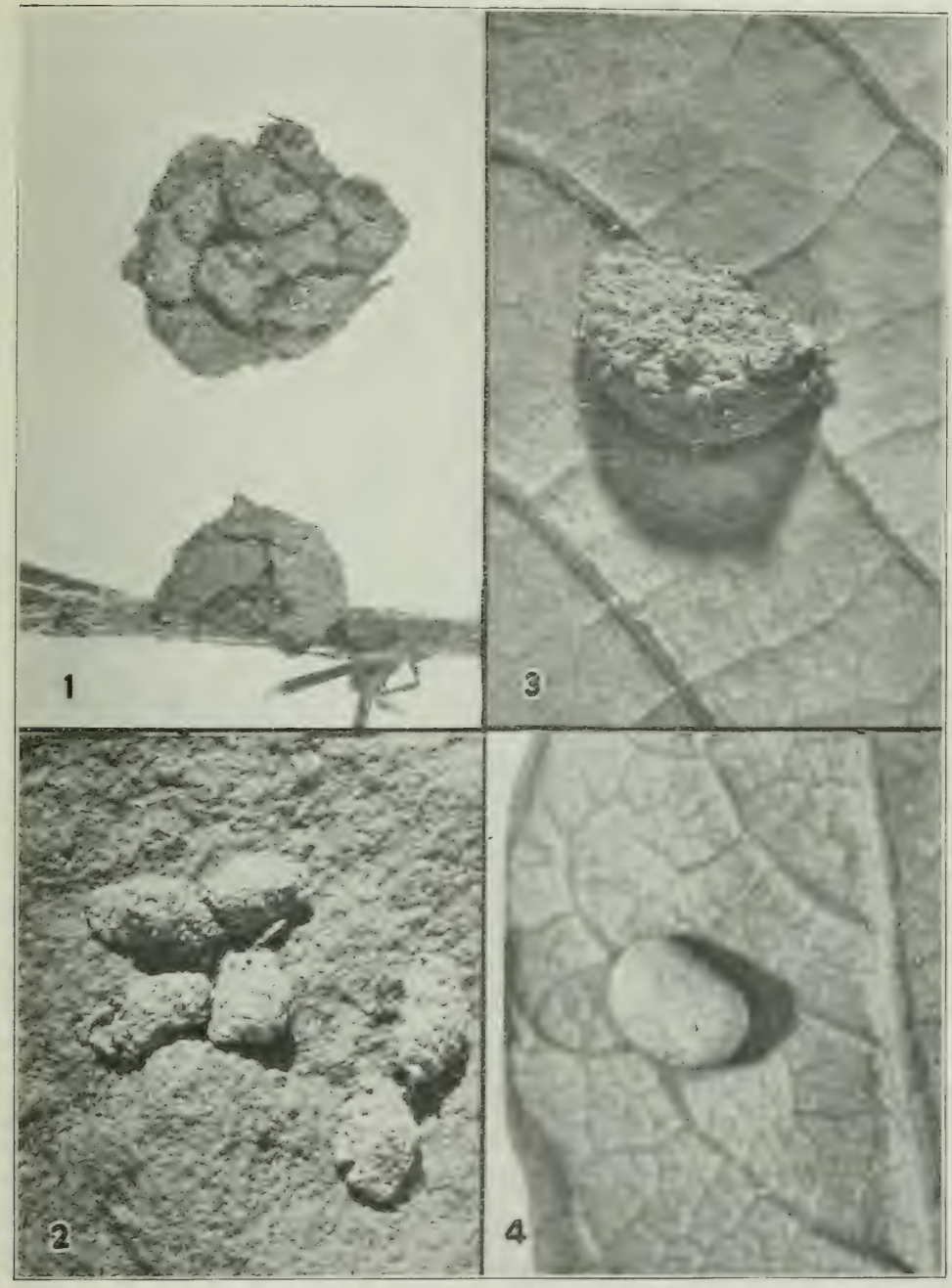
(Figures seven diameters.)

Fig. 1. Mud cells of *Chlaenius aestivus* on dead twig.

Fig. 2. Mud cells of *Chlaenius aestivus* showing lidlike opening for escape of the larva.

Fig. 3. Mud cells of *Chlaenius tricolor* on sedge, *Eleocharis tenuis*.
- a. Lateral aspect showing fold.
- b. Lateral aspect showing side opposite fold.
- c. Lateral aspect, fold removed showing egg.

Fig. 4. Mud cells of *Chlaenius cericeus*.
- a. Cell which was removed from surface of a stone.
- b. Cell on sedge.



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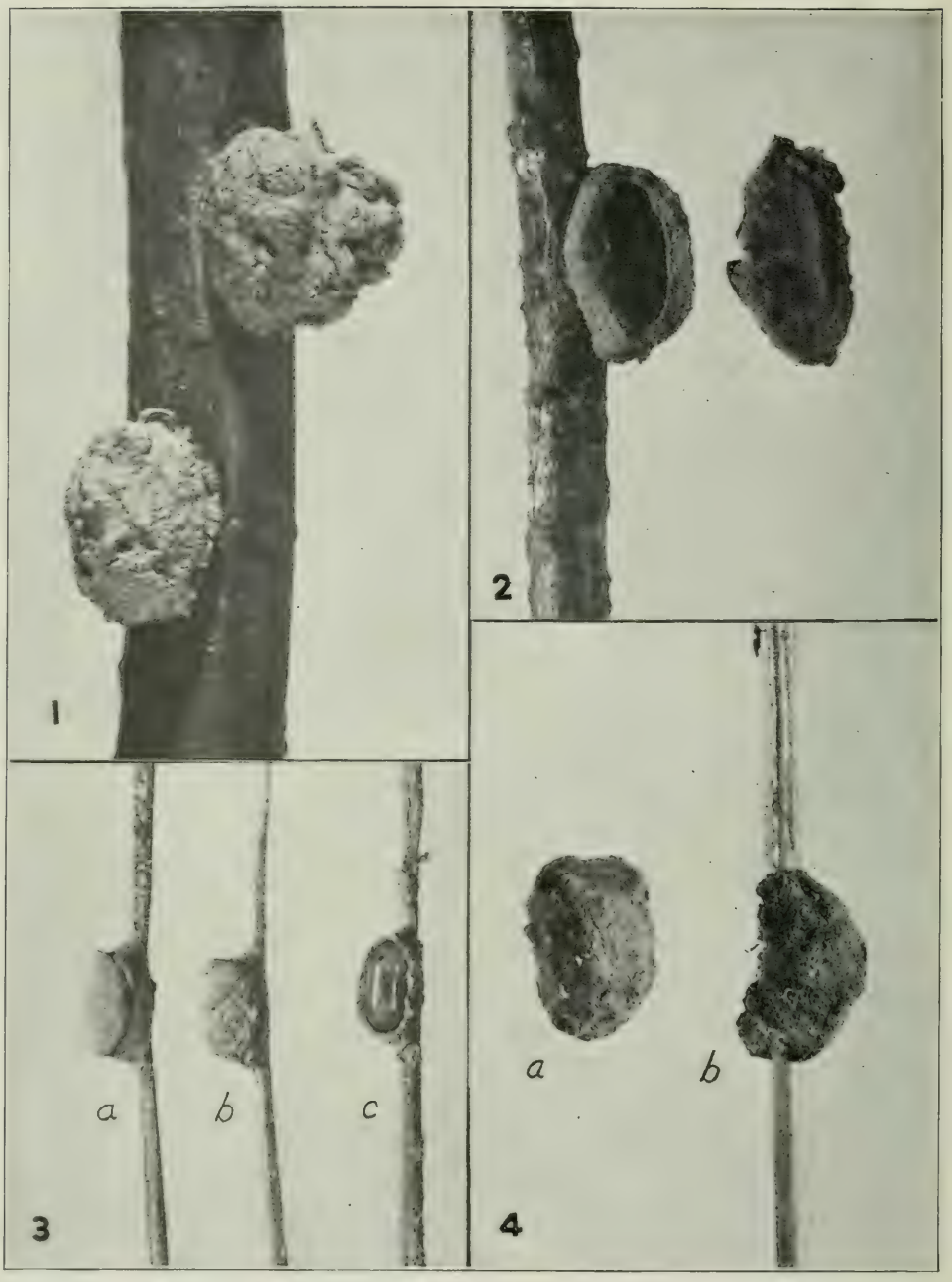

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